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TRANSACTIONS

OF THE

MICROSCOPICAL SOCIETY OF LONDON.

VOL. I.

THE

TRANSACTIONS

OF THE

MICROSCOPICAL SOCIETY

OF

LONDON.

VOL. I.

1844

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PREFACE.

In concluding the first volume of the 'Transactions of the Microscopical Society,' the Council feel it necessary to make a few observations upon the origin, progress, and present state of that Society.

It was founded in the year 1840, by the exertions of a few gentlemen engaged in scientific pursuits, for the purpose of affording assistance and encouragement to microscopical investigations, by promoting that ready intercourse between those engaged in such pursuits, by which not only are great advantages mutually gained, but also information of the most valuable kind disseminated and perpetuated. Another important consequence resulting from the establishment of this Society, and the increasing interest in microscopical pursuits excited by it, is the encouragement and stimulus given to the scientific makers of the microscope, by which that valuable instrument is now rapidly advancing to the highest degree of perfection.

The progress of the Society has been so satisfactory, that although the subscription is but one guinea per annum, the Council have been enabled, not only to pay its current expenses, but also to purchase for the use of the Members, three microscopes of the very finest description, with all the recent improvements, constructed by Messrs. Powell, Ross, and Smith, artists whose talents are too well known to need any comment here. It is also a subject of congratulation, that they are enabled to present the concluding part of this volume free of expense to

the Members; and they confidently expect that all future publications of the Society will in like manner be produced without any additional cost to the Members.

The present volume contains a number of extremely valuable papers, read at the meetings of the Society, upon a variety of interesting subjects, and illustrated by numerous plates: but it must be borne in mind, that the Society as a body, does not, by publishing them, consider itself as offering an opinion respecting any theories or conclusions advanced in or deduced from them. Their respective authors alone must be considered as responsible for them; and their correctness or fallacy left to be confirmed or refuted by future investigations.

21, *Regent Street,*
September 15, 1844.

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TRANSACTIONS

OF THE

MICROSCOPICAL SOCIETY OF LONDON.

I.—*On the Development of the Vascular Tissue of Plants.* By EDWIN J. QUEKETT, F.L.S., F.B.S., &c.

Read February 19, 1840.

THE vascular tissue of plants has frequently been the subject of investigation with the botanist; but even after what has hitherto been discovered and described concerning it, there remains much uncertainty in the minds of many persons as to its true nature, and as De-Candolle says, "of all parts of Vegetable Anatomy this has been the most disputed, and on which persons are still less agreed."

A study of this kind is naturally surrounded by many difficulties, on account of the minuteness of the objects to which our investigations are to be directed, and also to the delicacy of the manipulation required to follow out the subject in the youngest parts of a plant; and after attention to this subject, more or less, for several years past, I venture now to give publicity to the results of my researches.

It has been supposed that in structure vessels differ but little from cellular tissue, and that the elements of which the latter is formed are only altered and converted to fulfil a different function in the former, and that the development of the one will more or less correspond to that of the other; and from what has been observed, I believe this in great measure to be correct, the same idea being entertained by Slack in an interesting paper,* and latterly by that excellent observer Schleiden, in his memoir on *Phytogenesis.*†

The formation of the membranous portion of a cell has been satisfactorily described by Schleiden, who details the process as commen-

* Trans. Soc. Arts, xlix.

† Translated in 'Annales des Sciences Naturelles,' Seconde Série, xi. Botanique.

cing in the youngest parts of plants by the appearance of granules of various sizes in a kind of mucilage, which contains the nutritive materials, some of which collect together into one body, which encloses within it a rounded spherule: this mass so constituted he terms a *cytoblast*.* As soon as this has attained its full size, on some part of its circumference can be observed a pellucid glassy border, which increases in size and contains a gelatinous fluid; this border is the commencement of a minute vesicle, which continues to enlarge, and ultimately attains the perfect character of a cell; and the cytoblast, having performed its duty, becomes less and less, and in the majority of cases is entirely absorbed.†

Having examined nascent tissues since Schleiden's memoir on *Phytogenesis*, I am able to state that I have observed satisfactorily most of the appearances he describes that are connected with this subject; but still, I am under the necessity of stating that there are two other methods that others and myself also have often witnessed, by which cells are formed without the aid of a cytoblast, and the processes are quite as perfect. These methods are very well seen in some *Confervæ* and in some species of *Nostoc*, where a diaphragm is developed across the interior of a cell and divides it into two perfect ones, and this act is continually repeated. In *Chara*, as observed by Amici, and in *Torula cerevisiæ*, it is to be noticed that the young cell first appears as a small bud projecting from the margin of a perfect cell; this eventually enlarges, becomes hollow, and takes upon itself the same action: and in *Ergotætia abortifaciens* I have described ‡ the fact that both kinds of formations of cells may be witnessed in that very minute plant.

Respecting the origin of the membranous tube of a vessel, many theories have been advanced. Raspail says § that a vessel is created from a globule on the external wall of another vessel, and that a cell is created from a globule on the internal surface of another cell. And from this difference the vessel can elongate by insinuating itself between the tissues, and the cell, being confined in the interior of another, cannot assume an elongated form, and therefore he accounts for

* This body had been before described by Mr. Brown under the name of *nucleus*.

† It is a singular fact, discovered by Schwann, that animal cellular tissue is produced by an analogous method.

‡ Linn. Trans. xviii. pt. 3.

§ Nouveau Systéme de Physiologie Végétale, § 620.

the difference existing between the size and length of the cellular and vascular tissues.

Another opinion as to the method of formation of the membranous tube of a vessel has been adopted by Mirbel, Treviranus and Slack, which is, that this part of a vessel is formed from a number of cells being arranged end to end, which have their connections ultimately absorbed, so that there is produced one continuous cylinder instead of several separate cavities. I must state that in many instances I have met with arrangements of cells in such a way as would lead one to suspect that this was the true origin of a vessel; and it is a curious fact that cells adhere end to end much more strongly than they do side by side; therefore, when disturbed, they appear more frequently in strings than in other forms: but I believe no one has ever seen the fact farther than here described, or followed out the complete development of a vessel from this condition of cells; and there is one fact presently to be mentioned, connected with the development of a vessel, which entirely disproves this theory.

In order to watch the development of the membranous tube of a vessel, some part of a plant should be taken that is in a nascent state, being about to be developed into the organ it is intended to represent; for instance, a bulb or other bud answers the purpose, examining the scales from without inwards. But of all the parts hitherto found the most convenient is the young flower-stalk of the "long leek" (*Allium porrum*), which, in the state in which this vegetable is usually sent to the market, is found to be about an inch or more in length and from a quarter to half an inch in diameter. This organ occurs very low down amidst the sheathing bases of the leaves, and from having to lengthen to two or three feet, and containing large vessels, forms a very fit subject for ascertaining the early appearances of the vascular tissue.

To examine the development of vessels, it is necessary to be very careful in making dissections of the recent part, in order to witness the appearances to be detailed; and I have found it often more suitable for the purpose to macerate or boil the part used for a short time, until the tissues allow of being easily separated from each other.

When the examination is directed to discover the larger vessels, it will be found that at this early stage they present merely the form of very elongated cells arranged in distinct lines, amongst which, it appears extraordinary that some vessels are already arrived at maturity, especially the annular, even before the cytoblasts have disappeared from any of the cells of the surrounding tissue. The young

vessels, at this period, are with difficulty recognized from elongated cellular tissue, except from their very attenuated form, their ends being more pointed and containing a single cytoblast, much larger and more elliptical than that of any cell of the surrounding tissue.* In the bulb of *Scilla maritima* the young vessels appear at first under the form of a cell shaped as if composed of two very acute cones applied end to end, there being scarcely any cylindrical portion between them. As development proceeds the vessels rapidly increase in length till they arrive at perfection, but not so in diameter, for the dimensions in that direction are attained almost from the first formation.

At this period, in the living plant the young vessels appear full of fluid, which is apparently, as Schleiden remarks, of a thick character, and which he has designated *vegetable jelly*; but if boiling have been employed or alcohol added, the contents, or at least the albuminous portion, become coagulated, and every cell appears from this circumstance to contain another within it in a shrivelled condition; which appearance did not exist before the application of heat or of alcohol, and occasionally the shrivelling goes to the extent that all that can be seen of the contents is a thick granular cord extending down the vessel.

From these observations it is evident that the membranous tube of a vessel is formed on the same plan as the same part is in ordinary cells, and which act is entirely perfected before the commencement of the formation of the fibre within. And the occurrence of the cytoblast, and only *one* in each vessel, clearly demonstrates that the ends of several superimposed cells have not been absorbed to make one tube of greater length; if so, we should perceive as many cytoblasts as there had been cells so appropriated: but the fact is the reverse; one only is found, and that of large size, bearing the same proportion to the dimensions of the vessel as every cytoblast does to its own cell.

As long as the cytoblast exists, the commencement of the deposition of the fibre within cannot be observed, which fact, Schleiden mentions, takes place also in cells; in reality the vessel is not yet developed, and the fibre is only deposited when the contents assume a change that is observed after the disappearance of the cytoblast; but occasionally I have observed the commencement of the formation of the fibre whilst the cytoblast exists.

When this body has disappeared, the membranous tube of the vessel has by this time approached very nearly its perfect size, and I

* In this state they may be taken for ducts of the latex, and I have more than once seen circulation in them.

have found, as Schleiden has observed in cells, that the liquid contents become less transparent on account of numbers of the most minute particles, that can be just discerned by the highest magnifying powers, becoming generated in the interior of the vessel, from which it can be observed that fibre, and other deposits in the interior, have their origin; and it will be my purpose to describe what I have witnessed connected with these changes.

Schleiden imagined that there existed in cells a spiral current between the membrane and the jelly in their interior; * and mentions that Horkel had seen something analogous in the vessels of *Hydrocharis*, where a current, he said, exists between the spires of the vessel, and that this supposed current determined the direction of the fibre. In fact, to suppose there were such currents in the direction the fibre is deposited, which undoubtedly is most often spiral, what is to become of the fluids in motion when they arrive at the end of their spiral course? It is found that the turns of the spiral are nearly in contact in early life, therefore by what means can the currents be made to keep so distinct a course, and what could give them such a direction? If there exist any such current, it may account for the formation of a spiral fibre; but what kind of current could determine the direction of the fibre of a *reticulated* or *dotted* duct, or even an *annular* vessel? In fact the notion of a current preceding the deposition of fibre is, I believe, at most a gratuitous supposition, and insufficient to account for the several forms of fibre witnessed in the interior of vessels: and it is nearer the truth to imagine that what can be observed of that law which determines the direction of the fibre in one or more cases, may, with some modifications, serve to explain what happens in all, as it will be attempted to be proved.

From this conjecture of Schleiden's it is imagined that he had not seen the first commencement of this process, or if so, it is at variance with what I have observed in many cases, and which is particularly evident in the leek and in *Polygonum orientale*. When the young vessels are recognized† (which by experience becomes an easy matter, even in parts considerably developed, though not so at first). They appear as pellucid glassy tubes, with a cytoblast in some part of their interior; earlier than this they are not to be recognized readily from

* Annales des Sciences Naturelles, Seconde Série, xi. Botanique, p. 366.

† It is necessary in this examination to use the highest powers that optical science has furnished us with, and also to adopt all the means of adjustment and illumination that are found requisite for obtaining the most perfect definition; and especially making the observations by daylight.

cells. As they grow older the cytoblast diminishes, and the contents, which at first were clear and gelatinous, become less transparent from containing thousands of granules, which are too small to allow of the passage of light, and consequently appear as dark points; these atoms are about the $\frac{1}{50000}$ part of an inch in diameter, and have the motion known as "active molecules." If the vessel be wounded at this period the gelatinous contents pour slowly out, and then the singular movements of these molecules are still more clearly seen. These atoms, from their freedom of motion, are arranged indiscriminately in the interior of the vessel, but in a short time some of them enlarge, and then transmit a little light, which, on account of their minute dimensions, is not suffered to pass as a white pencil, but is decomposed in its course, the granule thereby becoming of a greenish hue. The granules exhibiting this greenish hue are now in a fit state to enter into the composition of the fibre that is to exist in the interior of the membranous tube, and in a spiral vessel this is the manner in which this act is accomplished.

The granules which are in active motion in the viscid fluid near one of the ends become severally attracted to the inner wall of the vessel, beginning at the very point; those granules first attracted appear as if cemented to the spot, by the viscid fluid in that direction losing some of its watery character, for there appears a string of a whitish colour, besides granules, in the line which the fibre is to occupy. As the other granules are attracted to those already fixed in an inclined direction, the spiral course is soon to be seen, and the same action progressively goes on, from the end it began towards the other, around the interior of the tube, in the form of a spiral; the fibre being produced, like a root, by having the new matter added continually to the growing point, thereby causing its gradual elongation.

This action is not throughout the vessel at the same instant, for I have witnessed a vessel having one half laid down with fibre, and in the other part the operation had not been commenced. When the granules have arranged themselves throughout the whole length of the tube, those which were first deposited, and had then some slightly visible space between them, have by this time been reinforced by others or nourished by the contents of the vessel, so that that space is obliterated, the fibre beginning to assume a threadlike shape with defined borders, and sufficiently large to allow of the transmission of white light. When this same action has progressed throughout the entire vessel, the transparency begins to be restored, and what is singular, the entire mass of granules has completely disappeared, appearing as

if the exact number and no more had been generated to form the fibre.* After the vessel has reached maturity, the liquid contents themselves become absorbed, as happens in the cells of the pith, and the vessel is then empty; and probably from being seen at different periods of its existence in these different states, sometimes full and at others empty, may account for the discrepancies existing among botanists as to the functions these vessels perform.

The period of the vessel's growth at which the laying down of fibre commences, determines the distance between the several coils, for instance, when it is first formed, the coils are quite close, scarcely any perceptible trace of membrane existing between them; if the vessel have completed its development the distance is preserved, but if the vessel have yet to extend its length, then as it elongates it separates the coils of fibre farther from each other, and frequently, as in the petiole of *Loasa contorta*, this is carried to such an extent, that at last the fibre is reduced from a spiral course around the interior of the vessel, to an undulated line extended through it longitudinally. Those vessels that are formed the earliest are always the smallest, and have the coils of the fibre most separated from each other.

In the *annular vessel*, the development of the cell and the adherence of the granules to each other are conducted in the same manner as just described, the direction of the deposit showing a tendency towards the spiral direction, by the presence of a spire connecting two rings, or by a ring being developed in the middle of a spiral fibre.

*The spiral does not always incline to the same direction, the "right-handed screw" being the most general, and the "left-handed" the least frequent. Often is it to be found that vessels contain more spiral fibres than one, in fact they vary from one to twenty in the same helix; and it occasionally happens, as in the spiral vessels found in the petiole of the leaf of *Loasa contorta*, that besides the spiral fibre there are other fibres extending longitudinally through the vessels, appearing as if the materials for the formation of the *spiral* fibre had not been exhausted, and that these longitudinal fibres (varying in number in different vessels) were the result of the appropriation of the remainder, to form secondary deposits. The development of these secondary fibres has not been witnessed, but it is imagined that they are developed from granules, as above described.

The shape of the fibre is not in all cases the same, being either semicylindrical, square, flattened, or, as Meyen has described in *Opuntia cylindrica*, lamelliform, and projecting some considerable distance into the interior of the vessel.

A general view of the process of forming a spiral fibre may be obtained by examining the hairs (rootlets) on the under side of the fronds of *Marchantia polymorpha* at different periods of their growth.

In some rare instances *forked* spiral vessels are to be seen, especially in the "long leek," in the tissue at the base of the bulb connecting it with the rootlets.

This vessel has the fibre developed in the manner already described, and I consider it to be the one that is first formed in the bundle of vessels of which it makes a part, and formed, not in the way we recognize it, but has degenerated from a spiral by two or more coils becoming united in a ring, and the fibre between these so formed rings becoming absorbed, as Mohl, Meyen, together with Schleiden,* have described. It is to be observed, as the first vessel, in the youngest parts of plants; and I believe its presence alone indicates a low degree of the organizing power, by its occurrence in *Equisetum* and *Lycopodium*, where it is frequently without any other, and which plants, in the ascending scale of vegetation, are almost the first that possess vascular tissue: and that the spiral fibre occurring with the rings marks a higher step in the scale of organizing power, that the true *spiral* more so, and the *reticulated* and *dotted* mark the highest. This being the order in which we find these several vessels placed in herbaceous exogens, proceeding from within outwards, and also developed; the differences of structure of the several vessels being indices of the vital energy of the plant, at the several periods of their development.

In those vessels in which the annular or spiral character of the fibre is more or less departed from, some curious modifications of the above process are to be observed, as in the *reticulated vessels*, such as are met with in the common balsam (*Balsamina hortensis*). The commencement of the formation of the fibre in these vessels is marked by the tendency of the granules to take a more or less spiral course; when it happens in the lines thus marked out that some one of the granules becomes enlarged by new matter deposited about it, this granule so altered becomes the point which gives an origin to another fibre or branch, which becomes developed by the successive attraction of granules into bead-like strings, and takes a different direction to the original fibre, forming a cross bar or ramifying, thereby causing the appearance by which this vessel is recognized.

In the *dotted* or *marked* vessels,† the fibre scarcely presents any

* Annales des Sciences Naturelles, Seconde Série, iii. Botanique, 373.

† The author, from the great difference which is to be found in the *dotted vessels*, has been induced to distinguish four kinds, sufficiently distinct from each other, and which occur almost exclusively in particular classes of plants, and which are to be recognized by the following characters.

- Markings rounded (*dots*)
  - placed without order
    - dots plane,.... *Dotted* vessel; a long slender vessel found in herbaceous Exogens.
    - dots with central mark,.. *Exogenic* vessel; a very short large vessel, in woody Exogens.
  - arranged in rows, ... *Endogenic* vessel, a very large long vessel, in Endogens and a few Ferns.
- Markings linear, ... *Acrogenic* or *Scalariform* vessel, in Ferns.

trace of spiral direction (still some of these vessels unroll spirally), and it has been found in their development, that the granules do not arrange themselves in a simple line at first, but that they adhere to each other in such a manner that all the branches of the fibre, that interlace with each other and leave meshes between them, proceed in their development at the same time; much like the growth of *Hydrodictyon utriculatum*, either beginning at one end of the vessel, and proceeding spirally towards the other, or beginning lengthwise and extending around the interior of the membranous tube, the several ends of the fibres being simultaneously growing points.*

In the *dotted vessel* the ramifications of the fibre are most frequently irregular, and are formed in the same manner as in the reticulated vessel. In the development of the fibre in the *Exogenic* vessel, which can be well examined in the young shoots of the willow, I have found that the development proceeds much in the same manner as before described, viz., by the granules adhering each to another in various beaded lines, so as to form a fibre or deposit of a reticulated arrangement, the meshes of which correspond to the dots on the surface, as in the way described. There is one singular character belonging to the dots on this vessel which distinguish it from the preceding, which is, that every dot has a central mark or smaller dot, usually of a singularly red colour, and which, when highly magnified, appears as a minute garnet set in the centre of each dot; and by this structure these markings approach those on coniferous wood, and I believe them to be of the same nature, from gradual transitions observed in the vessels of *Zamia Altensteinii*, and figured by Link in his 'Philosophia Botanica.' This red colour is owing to the dot being somewhat hollowed or cupped, and the centre being only thin membrane, and the passage so small for light to be transmitted, that it becomes decomposed; if charred very black and immersed in Canada balsam, this view is rendered perfectly satisfactory by its appearing the most transparent point.

In the *Endogenic* vessel, the connecting branches are given off under each other, so that the dots, which are here also rounded, are

* In the marked vessels it very often happens, though I believe never in spiral vessels, that the ends which are opposed to each other in two contiguous vessels are absorbed, so that a communication exists between them. In the *dotted* vessel it is most commonly that one aperture exists and the termination is rather dilated and suddenly acuminate. In the *Exogenic*, *Endogenic* and *Scalariform*, between the union of the vessels the membrane is absorbed and the fibres remain, so that several apertures exist (sometimes resembling a "grating") between the junction of two vessels.

arranged in longitudinal rows; and in the *Acrogenic* or *scalariform*, which vessels are generally angular and present distinct facets, the branches likewise come off in the same line, corresponding generally to the angles of the vessel, but the spaces left between are linear instead of round. Though these are the general characters, intermediate ones are found which bring these three vessels in very close relation to each other.

The dots thus left in these several vessels, which appear so evident, are not holes, as Mirbel, Richard and others have described, nor portions of fibre broken up, as Bischoff mentions, but are spots on the walls of the vessels where no deposit exists internally, corresponding therefore to the meshes of the fibres, where the external membranous tube of the vessel is unsupported; and on account of the extreme tenuity of this tissue, and the minute space between the fibres, the light in its transmission becomes decomposed, and every dot, under very high magnifying power, appears of a greenish red tinge, and with a low power as a dark spot. The structure of the dot is best seen by examining the broken edges of any such vessels, when it will be found that the fracture has been effected by the vessel giving way from one dot to another, so that the torn edge of the membrane can be observed in each dot.

From these observations we become somewhat acquainted with the minute processes Nature employs in forming fibrous deposits in the interior of vessels, which may not however be very different from the ordinary matter of lignification, yet it appears to me a mystery to understand what regulates this act of the plant.

Schleiden, speaking of fibro-cellular tissue,* imagined "que partout la spirale n'est qu'une modification de forme secondaire dans le produit de la force vitale (la matière des fibres), déterminé par une autre direction de l'action vitale de la cellule, lorsque celle-ci, arrivée à un certain degré de sa formation, est forcée d'abandonner son individualité propre et d'entrer comme partie intégrante dans l'être complexe qui constitue la plante entière." Or in other words, to explain this sentence, a cell at first possesses a perfect and independent existence, and forms its own membranous parietes; but when perfectly developed, it gives up its individuality when the vital power to form secondary deposits, existing in the plant, occasions the fibrous deposit. This reasoning, however, does not inform us what determines the granules to take on definite arrangements.

* Annales des Sciences Naturelles, xi. Botanique, p. 367.

It appears to me that the only theory capable of explaining the direction of the fibre, is one that will apply to some peculiar laws existing between the granules themselves and between the granules and the vital force residing in the vessel or cell in which they are contained. There can be no doubt that at first the granules are in the jelly, consequently as they become sufficiently developed they acquire freedom of motion, and attraction commences between the wall of the cell and the granules, and it can be easily imagined how these numerous atoms may be induced to approach to the circumference of the vessel, but the difficulty of the proposition is to account for their doing so in a spiral or other determinate form, and always of the same figure in the same situation in the same plant.

Some part of the law, I believe, is made tolerably clear, viz., that fibre is composed of granules arranging themselves like beads on a string, which become nourished by the contents of the vessel until a perfect thread is the result, and the direction this takes seems to me to be the result of some special power residing in the vessel under the control of the whole plant, probably electrical; * and which is modified in the several vessels I have enumerated: farther than this I believe we cannot go, though nature occasionally alters forms, she seldom varies much in her laws, but what these may be it is forbidden the eye of man at present to detect, and they appear to me, though operating in such minute spaces, to be stamped with as much permanency of power in the formation of these curious and elegant organs, as those laws on a grander scale are in the fashioning of our own frame, or in the maintaining of the stability of the universe.

* If particles of gold leaf be mixed with water, and the chain from an electrical machine be made to convey electricity to the fluid, the gold particles arrange themselves in a spiral form; and it may possibly happen that the currents of electricity, which are continually passing from the earth to the air through the tissues and fluids of plants, may have some share in determining, in the same manner, the spiral direction of the floating elements of the fibre.

II. — *On the vascular arrangement of the Capillary Vessels of the Allantoid and Vitelline Membranes in the Incubated Egg.* By J. Dalrymple, Esq. (See Plate I. figs. 1 & 2).

Read July 22, 1840.

Some weeks since I was induced to attempt the injection of the incubated egg, with a view, if possible, of determining the type of arrangement in the capillary vessels of the different membranes proper to the embryo. Having procured some eggs from the Eccaleobion at the 19th day of the artificial process of incubation, I placed a small pipe in the omphalo-mesenteric vein, and threw in, towards the chick, a minute injection composed of parchment size and vermilion. I had the satisfaction of seeing the bird immediately become red, and, shortly, the coloured fluid returning by the arteries, the allantois and vitelline sac became beautifully injected. Having thus succeeded beyond my expectations, I carefully separated the allantois from the membrane of the shell, and placed it in water beneath the field of the microscope.

Many large trunks of a somewhat tortuous character were observed giving off smaller lateral branches, which, frequently subdividing and inosculating, presented a beautiful appearance even to the naked eye. These vessels are constantly seen injected with blood, on opening an egg some few days prior to the completion of the process of incubation.

It is this vascular membrane to which has been attributed, by nearly all the most celebrated physiologists, the function of respiration during the embryonic life of the chick: but at various times, and even very recently, doubts have been thrown upon the truth of this theory of the function of the allantois, by reports of eggs hatched in various irrespirable gases, or when the atmosphere has been excluded by various coatings applied to the shell. I was anxious, therefore, to attempt to obtain, by artificial injection, a view of the capillary arrangement of these vessels, having been much shaken in my previous belief as to the respiratory nature of this surface by the late ingenious experiments of Mr. Town, published in the Guy's Hospital Reports: —experiments, I must be permitted to say, suggested to that gentleman by the truest principles of inductive reasoning, and executed with a tact and delicacy that do him infinite honor. It has subsequently appeared, however, by the experiments and tests of our President,*

* Professor Owen.

that the coatings applied by Mr. Town have not in all instances prevented the permeation of gases. Hence the question remained in much the same state as previous to the researches of Mr. Town, in regard to the function of this particular membrane.

As I had found by frequent observation that almost every tissue in the animal body is characterised by a peculiar arrangement of capillaries, so uniform in its type as to render it no very difficult matter to determine the nature of the tissue, and hence its function, by the microscopical appearance of the vessels alone; I was induced to believe that the vascular layer of the allantois, were it a true pulmonary structure, would present that definite character in its capillary vessels that exists in the vesicular lungs of some of the inferior Vertebrata.

The arrangement, then, in this allantoid membrane, consists of an infinitely minute distribution of capillary vessels of nearly equal size throughout its inner layer, forming an uniform vascular surface covering the large trunks as well as the interspaces of their subdivisions: the anastomoses of the capillaries are so numerous and close, that the areas they leave do not exceed the diameters of the vessels themselves, even when the membrane is somewhat stretched, as in the preparation I shall have the honor to submit to the Society this evening.

There results from this structure an infinite subdivision of the chan nels of the blood, presenting a most extensive surface in a limited space, to the action of the air, which permeates the shell and its proper membrane.

If the vascularity of this membrane be compared with the lung of the frog, salamander or serpent, the similarity of the type will be at once evident, and carries with it a strong corroboration of the previous theory of the respiratory character of the allantois in birds. It must be remarked, however, that as the blood-corpuscules of the Reptilia are much larger than those of the bird, so the capillary vessels of their lungs are of much greater size than in the specimen of allantois brought to the Society to-night; the difference between them being one of proportion, not of type.

The other preparations explain the character of the vascularity of the vitelline membrane at the 19th day of artificial incubation.

Immediately surrounding the remains of the vitelline area are seen on the internal surface of the yolk-sac, the commencement of a series of radiating folds, which dip deeper and deeper into the interior of the sac, presenting an elegant series of undulating plicæ, which increase in depth as they advance, and separate more and more from each other. These folds appear at first sight to consist of a simple granu-

lar membrane, having a number of coils on their surface, not unaptly to be compared, when magnified, to the convolutions of the small intestines. If all the fluid yolk be removed by gentle and repeated washing, and the vitelline sac be successfully injected, we nevertheless do not observe any very remarkable vascularity. Large yellow trunks appear dividing into small branches at the base of the folds, and *seem* to contain the yellow globules of the yolk, but the red color of the injection is only here and there apparent. These vessels are the so-called *vasa lutea* of Haller; but it is certain, I believe, from these injections, that the vessels do not contain the yellow corpuscules, but that these yolk-globules are super-imposed and external to their parietes.

This fact seems to have struck Burdach and Von Baer, from whose researches Burdach appears chiefly to have compiled his account.

This author, describing the vessels of the vitelline sac at the 8th, 9th and 10th days, says "they are covered with a thick layer of cellular tissue containing the yellow vitelline globules which color it. Also the small branches, which contain little blood (vasa lutea of Haller), appear themselves yellow. But it appears to me doubtful whether they admit the vitelline matter without change. It is perhaps only the liquid part of the yolk that is absorbed by the veins, for at the close of the 10th day its diminution (the contents of the yolk-sac) is more considerable than could result from the passage of this substance through the vitelline canal, and the blood is so little colored in the small venous branches, that we recognise its mixture with water very slightly coloured."*

When, however, by repeated ablutions, and by directing a stream of water over these folds, we detach the granular matter completely, we behold an exquisite vascular structure that has few parallels for beauty in the animal economy. We then see that vessels alone constitute the framework of the undulating folds, the large trunks of which form the base, while innumerable lesser branches dip deeper into the interior of the sac, inosculating repeatedly, and terminating in a series of very tortuous branches that fringe the extreme edge of each plica. Numerous simple loops are observed, shooting from the sides of the larger trunks, and constituting the simplest type of vascular papillæ or villosities of mucous surfaces.

If then we conceive each trunk, anastomotic branch, in fact every single loop and vessel, thickly covered with an aggregated arrangement

*Burdach, Physiologie, vol. iii.

of the vitelline globules or nucleated cells, thus concealing the vessels and colouring them of a bright yellow, we shall have a true idea of the appearance of these folds previous to the manipulation resorted to to display the injection. This beautiful lace-work, which bears a near resemblance to the vascular arrangement of the ciliary processes of the eye, is recognised, but imperfectly described, by Burdach in the following passage.

Speaking of the mucous fold of the vitelline sac, he observes that "this descends into the mass of the yolk by undulating folds, which are already distinguished at the commencement of this period (11th day), but which nevertheless have acquired a depth of more than one line. These folds are themselves garnished with little wrinkles, and are evidently analogous to those which, among the superior Vertebrata, take the place of intestinal villosities. Each of them encloses a vein, and each wrinkle a little vein."*

Having sedulously attended the admirable lectures of our President this summer at the Royal College of Surgeons, upon the subject of development of the egg, and not having heard any allusions to artificial injections, I was induced to try this method to determine the character of the allantois: nor was it until after I had been struck with the beauty of the structure of the vitelline sac, that I consulted any authorities on this subject. The relations of Burdach are so meagre in respect to the vascular arrangement of the capillaries, that I greatly doubt whether the facts brought now before this Society were fully known to that writer. I have subsequently inspected the preparations of the Hunterian collection at the Royal College of Surgeons, and find three injections of the allantoid membrane: in two, the injection has not been successful enough to enter a single capillary vessel, while the third appears to be very greatly extravasated, so that it would have been impossible to determine this question from any of those preparations, while there does not appear to be any specimen of injected vitelline membrane at all. The true nature of this structure, therefore, appears to rest upon the imperfect relations quoted from Burdach's Physiology.

I have thought it necessary to throw together these few observations simply with a view to render intelligible the preparations I shall have the honor to submit this evening to the attention of the Microscopical Society.

6, Holles St., July, 1841.

* Burdach, Ibid, 11th, 12th and 13th days.

III.—*On a new variety of Vascular Tissue, found in a fossil wood from the London Clay.* By James Scott Bowerbank, Esq., F.G.S.

Read October 21, 1840.

The singular variety of vascular tissue which is the subject of this paper, occurs in a fossil dicotyledonous wood from the London clay of Herne Bay, in Kent. The texture of the mass is unlike the greater part of the fossil woods of this formation, which are either composed of solid carbonate of lime, as in the specimens from Harwich and its neighbourhood, or of iron pyrites, as in the small pyritical fragments of stems and branches so numerous among the shingle beneath the clay cliffs of the north shore of Sheppey. The specimen under consideration is very similar in appearance to Bovey coal, but more friable and carbonaceous. With a low power a longitudinal section of the wood has very much the same appearance as a similar section of beech wood. When a thin slice is viewed as a transparent object with a power of 100 linear, it exhibits numerous large vessels, the greater part of which are of that variety of annular vessel which has the annulations very much interrupted and divided into numerous portions of various sizes. Occasionally large vessels are seen, thickly covered with minute dots, having a dark line passing over the centre of each, at right angles to the axis of the vessel, (Pl. ii. fig. 1). If we increase the power to 800 or 1000 linear, the structure of this curious appendage to the discoid organs or dots is rendered apparent, and we find that each of these transverse markings is composed of two lines, separated from each other at their centres but uniting at either extremity, (Pl. ii. fig. 2). In most cases these lines do not extend over the surface of more than one dot, and their united ends project slightly beyond its margin, but a few instances may be seen of their extending over two, three, and even four dots, and then the lines are observed to expand to the greatest degree over the centre of each of the dots, and to approach each other slightly in the spaces between them. The lines and the dots, when viewed with a power of 1000 linear, do not seem to be precisely in the same plane, the latter appearing to be in the membrane on the outer surface, and the former in that of the inner surface of the vessel. When thus highly magnified, the dots exhibit the same structure as in the similar but very much larger organs that are so well known upon the dotted ducts of the *Confervæ;* having the same lenticular form, and being furnished with a central area or orifice, which is very apparent when the external surface of the vessel

is examined; but when its internal surface is viewed, it is mostly obscured by the double line which passes immediately across it. Upon showing this curious tissue to my friend Mr. Edwin Quekett, he kindly favoured me with some thin longitudinal slices from a stem of *Piper nigrum*, in the vessels of which he said he had observed a tissue of an exceedingly similar nature. Upon comparing these with the fossil specimens, the tissues appeared to be precisely of the same construction, the only observable difference being that in the vessels of the recent wood the dots and the double lines were more minute than in the fossil tissue.

There is very little doubt, therefore, that our fossil is either a true *Piper*, or very nearly allied to that genus; and this is rendered the more probable from my having found several specimens of fossil fruits from the Isle of Sheppey, which bear a striking resemblance to those of some of the existing species of the *Piper* tribe.

There is another remarkable circumstance attending the examination of this fossil wood. Some of the vessels contain large vesicular globules, which appear to have been floating freely within their parietes, (Pl. ii. fig. 3—5); when not in contact with each other they are perfectly globular and uncompressed: they vary very considerably in size, in some cases filling nearly the whole diameter of the vessel. The structure of which these globular bodies is formed is thin and very pellucid, and no fibre or other organic structure is apparent upon its surface. There are also, in some of the vessels, exceedingly small vesicles interspersed among the larger ones, (Pl. ii. fig. 3 *a*); a portion of these are opaque and black, but the greater number of them are transparent like the larger ones. These very minute vesicles do not exceed the globules of circulation in *Vallisneria* in size; and as we find vesicles of every size intermediate between these minute ones and the largest of the vesicles, it appears probable that the whole of them may be attributed to a more than ordinary development of the globules of circulation, analogous to those observed tn *Vallisneria* and other plants.

I have never seen this curious form of tissue in any other wood, either recent or fossil, but I have occasionally observed similar large pellucid globules slowly moving in the great central cavity of the stem of *Chara translucens*, while the circulation of the smaller globules in its parietes has been proceeding with a much greater degree of rapidity.

Where the lapidary's process has removed portions of the larger vesicles, as represented at *b*, fig. 3, 4, pl. ii, there is a granulated appear-

ance in the sections of the walls of these organs, as if their parietes were composed, not of a single simple membrane, but of two such membranes with molecules or exceedingly minute vesicles interspersed between them. I have carefully examined the cuttings of the wood of the recent *Piper nigrum*, but have been unable to detect the slightest indication of the existence of similar vesicles in any part of its structure.

Note.—Having been present at the reading of Dr. A. Farre's paper "On certain phenomena observed in the genus *Nitella*, as illustrative of the peculiar structure recently discovered by Mr. Bowerbank in a fossil wood from the London clay." I was induced again to examine the cuttings of fossil wood, and I observed that there were, in many cases, the remains of circular granulated masses, which were either attached to or reposing upon the large vesicular bodies, as represented at *c*, fig. 3—5, pl. ii. or sometimes, although rarely, floating freely within the parietes of the vessel, as at *d*, fig. 4, pl. ii. When examined with a power of 1000 linear their granulated structure is very apparent, and they present a striking resemblance to the granulated masses described by my friend Dr. A. Farre, but they differ in situation, as in the fossil they were always without, while in *Nitella* they are situated within the vesicular body. Their situation in the fossil vesicles, supposing them to be projecting from the surface but covered by the outer filmy coat of the vesicle, would render them, both in situation and structure, exceedingly similar to the cytoblast and the cell which it developes, as described by Schleiden; but the same idea will not apply to the granulated masses in the recent plant, unless it be that in this case the aggregation of the globules of circulation is the first step towards the formation of a cytoblast, or of a congeries of those organs: but this is a question of such an occult nature, that I but humbly presume to suggest these ideas in the hope that it may induce others who are much better acquainted with vegetable anatomy and physiology, to endeavour to work out this interesting and difficult problem.

IV.— *On certain Phenomena observed in the genus Nitella, as illustrative of the peculiar structure recently discovered by Mr. Bowerbank, in a Fossil Wood from the London Clay.* By ARTHUR FARRE, M.D., F.R.S., &c.

(Read November 25th, 1840).

THE observation of a new form of vascular tissue occurring in the fossil wood from the London clay, as detailed by Mr. Bowerbank in his paper read at the last meeting of the Society, has induced me to offer a few remarks on an apparently analogous *recent* structure, which I, several years ago, observed in some specimens of *Nitella flexilis*, kept for the purpose of examining the circulation in that plant.

Before proceeding to detail the result of my own observation, I may be allowed to quote that portion of Mr. Bowerbank's paper in which this new fossil tissue is described. The author observes that in the Herne Bay fossil "some of the vessels contain large vesicular globes, which appear to have been freely floating within their parietes; when not in contact with each other they are perfectly globular and uncompressed." "They vary very considerably in size, in some cases filling nearly the whole diameter of the vessel, while in others they do not occupy a tenth of that space. They are frequently so numerous that they fill the whole of the vessel. The structure of which these globular bodies is formed is thin and very pellucid, and no fibre or other organic structure is apparent upon its surface. There are also in some of the vessels, exceedingly small vesicles interspersed among the larger ones. A portion of these are opaque and black, but the greater number of them are transparent like the larger ones. These very minute vesicles do not exceed in size the globules of circulation in *Vallisneria*; and as we find vesicles of every size intermediate between these minute ones and the largest of the vesicles, it appears probable that the whole of them may be attributed to a more than ordinary development of globules of circulation, analogous to those observed in *Vallisneria* and other plants." The author further remarks that he has "never seen this curious form of tissue in any other wood, either recent or fossil; though he had "occasionally observed very similar large pellucid globules slowly moving in the great central cavity of the stem (of *Chara*), while the circulation of the smaller globules in its parietes has been proceeding with a much greater degree of rapidity."

These particulars, with reference to the structure of the fossil wood,

and the resemblance to *Chara*, so happily conjectured, are so completely borne out by what I have observed in *Nitella*, that the description of the one might almost serve for that of the other.

In some specimens of *Nitella flexilis* (Pl. ii. fig. 6) the circulation was observed to be going on vigorously up to the 4th of April, 1835: on the 6th, two days after the last observation, the circulation had entirely ceased. The green particles lining the interior of the stems and branches had shrunk from the parieties, and, together with the green circulatory matter of the interior, was collected together in irregular masses within the tubes, (Pl. ii. fig. 7); but none of the brown bodies afterwards observed were as yet apparent in any of the pieces.

On the 11th, five days after the preceding observation, and no intermediate one having been made, the same specimens were again examined, and were found to present characters which I had not before observed. In many of the joints, the irregular masses of green matter had resolved themselves into globular bodies of variable size but definite form, and had changed from a green to a rich brown color. About half of the joints had undergone this change, the other half remaining in the green state, as at the last observation, but the circulation had entirely ceased in all, and the plant was evidently dead.

In the greater number of those joints which contained the brown bodies, the green matter had entirely disappeared, leaving the tubes as transparent as glass, with the brown globules like rows of beads irregularly scattered in their interior, (Pl. ii. fig. 8 *a*, and fig. 9). These varied very considerably in number. In one long joint of the plant about eighty of them were counted, while in one of the short branches there were only five. Some of the larger bodies were about half the diameter of the tubes in which they were contained, while others were one eighth of the diameter. Those which were completely formed had all the same character. They consisted of tolerably regular spheres, except where their form had been slightly altered by lying in contact with each other. In almost all of them, however, and especially in the larger ones, there was a slight flattening or a cup-like depression at one point, which was generally observed to be directed towards the surface of the tube, and might have been produced by the globules coming in contact with the parietes of the tube, but was nevertheless retained after they were extracted from it. In the centre of the flattened portion or cup-like depression, there was always observed to be a small collection of granules, which were of the usual size of the globules of circulation, but also of a brown colour, (Pl. ii. fig. 10 *a*). The brown bodies, on account of the now transparency of the

containing tube, could be examined as readily *in situ* as when extracted from the joints. In either case they appeared to consist of an enveloping membrane, which was probably formed by the aggregation of the green granules of the plant, assisted by the condensation of the mucous fluid of the interior; and thus forming an investing capsule, which, when torn open, was found to be filled by the *green* granules of the plant mixed with mucous fluid, (Pl. ii. fig. 11). The investing capsule was very thin, and presented no other traces of structure than that which would arise from the formation of a membrane by the aggregation of granular matter.

In those joints in which the brown bodies had been formed, the green matter of the plant had in most cases entirely disappeared. In others, where they appeared to be in process of formation, they were observed to be mixed with the green matter; and in other parts again they had not yet undergone the change from green to brown, but showed themselves in the form of irregular masses of green matter approaching the spherical form.

It appears then that this remarkable change had taken place within a week after the circulation had been observed to be going on vigourously in the plant. And the nature of the change appears to be this. The green granules which line the internal surface of the living joints desert the parietes, and, together with the green circulating granules of the interior collect together in irregular masses in the centre of the tube, which then resolve themselves into irregular spheres, still retaining the granular outline, indicative of their formation by aggregation, but which they afterwards lose on assuming a more perfect spherical form, and become bounded by an investing capsule, which turns of a rich brown color, while the contained granules retain their original green.

It is difficult to imagine what purpose is intended to be answered by such a change taking place, after all circulation and other evidences of life in the plant have ceased. Yet the idea of such a change being the result of a merely fortuitous arrangement of the component particles of the plant attendant on decomposition, is negatived by the circumstance of the remarkable uniformity and symmetry of the resulting globules, which appear to possess the most definite characters, differing from each other only in size. Nor is the change by any means uniform for the whole plant; for in some parts two of the joints were observed to be in the green state, while the joint situated between them was free from green matter and contained the brown bodies: but this might have resulted from the circulation ceasing earlier in the

central joint, and consequently allowing more time for the changes to take place.

It would appear that the enveloping of the granules by an investing membrane was a means of preserving the organic particles in a green and probably therefore in a living state. But whether for the purpose of regeneration under a different form (thus affording an example of equivocal generation), or whether the phenomenon was in any way connected with the reproduction of the plant, did not appear from any observation that I could make, as no further change was observed to take place in the brown bodies beyond that which has been described, though they were kept in water for a considerable time. An appearance similar to what appears to be the first stage of the process, is not unfrequently observed in the living *Chara*, where a number of the green granules collect together in a mass, which either passes along with the general circulation, or remains revolving at one extremity of the tube. But I am not aware that the brown bodies now described have ever been seen in the living plant, nor have I met with any observations which at all illustrate the point. The phenomenon however appears to me to bear very closely upon the remarkable form of tissue described as occurring in the Herne Bay fossil, and I have therefore been induced to bring it before the Society, together with the original drawings, which were made at the time of the observation, and the preparation of that portion of the plant from which they were made, and which, though it has suffered from being kept for more than five years, during which time it has become dry, will still, I believe, afford a fair idea of the structure alluded to.

These brown globules, contained in the stems of *Nitella*, appear to differ from the globules found in the vessels of the fossil wood chiefly in the circumstance of their being hollow spheres in the fossil, but capsules filled with green matter in the recent plant.

V.—*On the Structure of some Tissues possessing Hygrometric Properties.* By E. J. Quekett, F.L.S., F.B.S., &c.

Read November 25, 1840.

The observations contained in the following communication, will be found to have reference to the effects of *moisture* and *dryness* in causing various alterations in the form and conditions of many of the organs of plants, in the recent as well as in the dry states; and also it will be attempted to be shown that there is some peculiar structure and arrangement of the tissues in those parts where these effects are most manifest.

That there are hygroscopic properties in the tissues of plants cannot be doubted; and that these properties are not universal throughout the vegetable kingdom is also evident, by the fact being shown only in plants of particular orders, and in particular parts of various plants of all orders. As this quality is not general but special, it must be regarded in the light of an attribute of the plants so endowed by which they are enabled to exercise particular functions through this property, which are of essential importance in their economy.

Numerous are the instances where the abstraction from, and the addition of water to, portions or to some entire plants, exerts singular effects, which are found to be occasionally the very opposite in one part to that which happens in another; for instance, the application of moisture will cause a contracted portion to expand, and it will also cause a closed organ to open: the drying of the tissues will also effect the same changes, causing some organs of plants to open, and those which moisture opens to contract.

Instances of the first effects are very readily witnessed in the *mosses*, which, notwithstanding they may have been dried and shrivelled for very many years, yet when moistened they put on the appearance and characters of living specimens; some have even supposed that life is not extinct in these plants, after many years have been passed in this dry condition. There can be no doubt that this hygroscopic property of the tissues of mosses is a special provision, as they are destined to be in perfection in the winter months, and ripen in that season the means for their propagation; so that in the summer months, when the increased temperature quickly evaporates the moisture from their delicate cellular tissue, they shrivel and wither, yet they do not perish; but on the first rainy season of autumn they rapidly absorb the moisture that falls upon them, their tissues becom-

ing distended, and they again are prepared to go through the periodic performance of those functions which nature has assigned to them.

Other instances of this kind are found in the lowest tribes of Algæ, as in the *Gloiocladeæ*, which also will resume an apparently fresh state even after being dried for years.

One of the most beautiful however is to be seen in the *Lycopodium lepidophyllum* from Peru, where moisture has the twofold effect of expanding the contracted plant, and stimulating its dormant vitality.

Numerous are the instances in which moisture exerts similar effects which could be mentioned; but enough have been brought forward to illustrate the fact.

Examples where moisture causes closed seed-vessels to open are not so numerous, but Decandolle mentions that Defrance has observed that the seed-vessels of *Epilobium*, and some other genera of the *Onagraceæ* (Evening Primrose tribe), expand when saturated with moisture and close when dry; which fact I have found to be correct in some respects. The seed-vessel of the *Mesembryanthemum* or Fig-marygold exhibits also, we are told, the same phenomenon.

The instances where the dryness of the tissues or the abstraction of moisture causes a separation and an opening of the cavities of seed-vessels and other organs, are exceedingly numerous; and some of the most beautiful contrivances have been contemplated by nature to perform various functions consequent on the changes these organs undergo, when the aqueous contents are abstracted from their tissues by that law which is impressed upon them, and operates in the season of the maturation of the fruit.

To bring forward instances of this nature, I shall select only the most common examples in which the effect of dryness in the tissues has the property of preparing the way for the dispersion of the seeds. If a poppy-capsule be examined when ripening, numerous valves or trap-doors can be discovered beneath the radiated crown, which are intended to give exit to the numerous seeds within. If the ripened seed-vessel of the *Rhododendron*, or that belonging to any of the species of *Dianthus*, *Silene*, *Cerastium*, *Geranium*, *Erodium* or *Cardamine* be examined, there will be found beautiful contrivances in all these for effecting the dispersion of the seeds by loss of moisture.

In all these examples this act is performed gradually and silently, but in some particular plants it is accompanied by a very loud report, and the seeds are violently ejected. This happens in many species of *Banksia*, and still more remarkably in *Hura crepitans*, the sand-box tree of the West Indies.

Besides these contrivances for dissemination, such as *valves, springs* and *explosions,* many others may be noticed of an hygroscopic nature; but amongst the various contrivances none can scarcely exceed the ingenuity displayed in those parts which are destined for aërial flights, and which cannot be exceeded by the skill of the aëronaut: notwithstanding Nature does not inflate a hollow bag with a buoyant gas, still she fabricates a machine which is capable of being wafted on the lightest winds, carrying with it a parachute containing the living germ to ripen its produce in some distant spot; — such contrivances being mostly manifested in the *Compositæ,* and especially among the *Thistles.*

There is another act performed by the aid of moisture and dryness which approaches somewhat near to locomotion: this occurs in the fruit of *Erodium,* and in the parts surrounding the fruit of *Avena fatua,* commonly known as the "*animated oat,*" where, by the twisting by dryness and untwisting by moisture of the awn, change of place is the result.

Notwithstanding the parts selected here as examples are entire organs, and where the hygroscopic action is most marked, still all parts of plants and all tissues are more or less susceptible of absorbing a certain amount of moisture, which causes an increase in their bulk. This is seen in woody portions, as in doors, which close well enough in summer, but are so enlarged by the damp of winter as to be closed with difficulty, yet regain their natural size on the return of the dry season. This reciprocating condition of ligneous parts has been satisfactorily and ingeniously shown by Mr. Edgworth, who has contrived to convert this alternate state of expansion and contraction into a power acting in one direction, and thereby he has contrived to convert a peculiar form of *wooden stool* into a locomotive machine.*

Enough has been said to establish the broad principle of the hygroscopic properties of vegetable tissues in particular instances, and in the next place it becomes necessary to examine if, where these characters are so evident and accompanied with such marked effects,

* The stool was made of wood that absorbs moisture readily (deal cut endways from the plank was used by the author), and into it fixed four legs, inclining all in one direction, at about 20° with the top, each terminated with a point of metal, which, from the inclination of the legs, would only allow the stool to be moved in one direction. As it expanded by moisture it would cause one pair of legs to recede a small space from the other, and when it contracted, the legs that first receded could not be again brought to the spots from which they moved, but the legs which remained fixed by expansion now will be moved by contraction, and by the changes occasioned in the wood by expansion and contraction, caused the stool to move always in the same direction.

there can be discovered by the microscope anything in the arrangement and nature of the tissues of those parts which exhibit the above alterations and separation of their several portions, that will account for these changes satisfactorily.

In plants like mosses or other vegetables which merely expand and contract by the application of moisture, without disturbing the relation the several parts bear to each other, nothing can be seen in such beyond the ordinary character of cellular tissue, and in all probability the avidity for water in these plants depends upon some different chemical characters of the tissues themselves, when contrasted with cellular tissue not so hygroscopic; this power of absorption being always most in new, and in those tissues which are devoid of deposits.

When however other examples are examined where evident displacement or separation of parts obtains, and this always in the same direction and attended always with like results, then it can be discovered that not only is the tissue more hygroscopic at that part, but the arrangement is such as to ensure the effect nature has intended. Let us take, for example, the capsule of some plant of the order *Caryophylleæ*, as *Cerastium*, and it will be found that when that organ approaches maturity, the apex, which was pointed and entire, will open by splitting into five equal valves, which curl outwards, making one complete coil, and always in the same direction; by the application of moisture the valves will resume their original position, and when dry take on the curled form again.

If one of these valves be examined it will be found to be thin and diaphanous where it forms part of the body of the capsule, but where it is hygroscopic it is horny and opaque. When a section taken from the edge of the valve or curled part longitudinally is examined by the microscope, it will be found that the tissues will be different on the exterior and internal surfaces, both however cellular; but the inner layer, or the cells of the convex border, are of different dimensions from the outer, being neither so large nor having so thick walls, (though they are thicker than ordinary cells); whilst those of the outer layer are almost solid, and the only cavity they have is indicated by thin spaces between a series of lines, the chief one of which is in the direction of the longer axis of the cell, the others connected to it at right angles. These cells are of most curious structure, and form an interesting object for the vegetable anatomist.

In this arrangement of parts it must be evident that by the shrinking of the tissues of the seed-vessel by loss of moisture, there will occur unequal contraction, and that side will be curved which con-

tracts the most forcibly, and by this curvature one valve must necessarily be removed from the next, evidently showing that the tissues act as unequal antagonists to each other.

A very analogous effect can be observed in the species of *Geranium*, which, if examined before the fruit is quite ripe, will be found to have the several carpels attached to the base of an elongated receptacle, and the apices of each (styles) to be attached to its whole length. When maturation arrives, by the loss of moisture the lengthened apex of each carpel evinces a tendency to be curved outwards, and this tendency increases to such extent, that ultimately it overcomes the adhesion which existed between the receptacle and itself, excepting at the point, and separates from it with considerable elastic force, and ejects the seed from the carpel through a naturally formed aperture, at the same moment when it assumes a curved form, still maintaining adhesion by its apex to the receptacle.

If this elongated portion of the carpel be examined, either by making a transverse or longitudinal section, which can be well done in *Geranium sanguineum* or *dissectum*, it will be readily seen that the part which curves is composed of two tissues of different colours and densities, the most dense being situated externally and on the concave face of the organ; the effect being exactly similar to that produced by riveting together a flat piece of brass to a similar piece of steel, and exposing the whole to the same temperature. As these expand unequally when heated together, a curvature is formed, the convexity of which, of course, will be on the side of the most expansive metal.

The elongated beak of the carpel of *Erodium cicutarium* and other species is, like the *Geranium*, attached to an elongated receptacle, which it leaves not by a sudden elastic spring, but by the carpel becoming detached first, and then the apex twisting several times, until at last it separates itself from the receptacle. In the structure this elongated portion of the fruit is somewhat like the *Geranium*. It presents in the transverse section an elliptical outline, and exhibits on one side a tissue composed of woody fibres, with extremely thick parietes, there being scarcely any canal in their interior, and on the other a still more dense tissue; at the spot where these tissues unite the fibres possess a greater canal and a looser character, which appears a change gradually effected on one side only, for where the fibres possess the greatest calibre, there is no gradual diminution towards the other of their thickness.

The organ is not composed equally of the two kinds, but one occu-

pies about four fifths, the other the remainder; if these tissues of unequal density occupied an equal share of the organ, a strong curve would be the result; but as the *Erodium* has no aperture to eject the seed if there were a sudden jerk attending its separation, that act is not required, consequently the apparatus for disengagement is somewhat modified.

It appears from observations that besides this arrangement for producing an alteration of form, that there exist some peculiar hygrometric properties; for when longitudinal sections of this portion are placed under the microscopic and water is added, they do not appear to expand equably, one side expanding before the other, and appearing to slide in advance of it. If this be the case in the entire organ, it is readily seen that it is obliged to accommodate itself to the spiral form by losing the moisture from its tissue.

By far the most curious set of hygroscopic actions are manifested in the expansion of the *pappus* or seed-down of some plants belonging to the order *Compositæ*. The calyx of the florets of these plants does not put on the leafy character common to most flowers, but is composed of many curiously constructed feathery hairs, which appear to be the representatives of that organ in a very rudimentary condition; and by the design of Nature is destined to serve a most curious part in the dissemination of these plants. When the seed-down of *Cnicus eriophorus* is examined in its natural situation, it is found to be arranged on the apex of the fruit, like the hairs in a pencil brush, crowded amongst hundreds belonging to other florets, and so compressed by those by which it is surrounded, as to be unable to expand the numerous parts of which it is composed; but by the continued drying of the tissues the whole mass of seed-downs partakes of the same struggle to expand their rays, and coupled with the contraction of the receptacle on which they are situated, the numerous mass becomes at length detached. When freed from the pressure of each other, the heat of an autumn day causes the expansion of the several filaments, which, radiating from the same centre, soon arrange themselves into a globular figure, the seed being attached to the centre. In this state each becomes the sport of the wind; the passing current wafting it from its place of birth, bears it away, and it obeys the dictates of the element till the breeze slackens, when it descends slowly to the earth, and if the place of its descent be charged with moisture, then its career is stopped, that becoming either the place of its growth or of its destruction.

Such is the nature of the office of this seed-down, but the most in-

teresting part is to determine in what manner this appendage to the fruit is converted by a little sunshine or increased temperature into a globular shape. My attention was given to this subject from observing so many of these spheres floating in the air in the most dense parts of this metropolis in October last, which showed how perfectly the apparatus which Nature had contrived answered the purpose, for it must be evident that they must have grown many miles from the heart of the city, where several specimens were taken whilst descending to the earth.

It was imagined at first that the mechanism was something similar to the spines of an *Echinus*, being articulated to the apex of the fruit, and when the fruit contracted by drying the points of attachment became more approximated, and caused the several rays to expand;—but on more minute examination it was found that the seed-down was not connected directly with the fruit, but all its rays were attached to a ring, which was easily separable, together with the entire apparatus, from the fruit, and still was capable of expanding and closing precisely as if it remained in its natural situation. In *Leontodon* and *Tragopogon* the pappus is elevated on the attenuated apex of the fruit.

To account for the radiated expansion of the filaments, seated around a thin ring, was still more difficult; which, on examination by the microscope, appears to be composed of minute granular cellular tissue, constituting a narrow band which connects the bases of the rays. On looking at the structure of the rays themselves, they were found to be composed not of one simple feathery hair, but that numerous fine hairs were condensed into a bundle, and the apices of the whole becoming detached at unequal heights, caused the feathery structure on their exterior. On examining the connection of the base of each with the ring, it was found to be wedge-shaped or conical for a slight distance up the shaft.

When these several parts are in their natural position, before expansion, it is not impossible, I conceive, that the shafts of the rays touch each other for some distance, and that the conical ends are therefore a little removed from each other; when the moisture has been dissipated the ring contracts, and by so doing brings the conical ends of the rays into close contact, and they are obliged to assume a circular arrangement by the extremities diverging and the bases approximating each other, like the wedge-shaped stones of an arch. If this force, which acts horizontally, be imagined to act also in every vertical plane, we may then have the several rays taking on the figure of the specimen. By the application of moisture the ring expands,

and the rays collapse to their original position. Notwithstanding this mechanical explanation may account for the fact in some way, yet some of the rays take occasionally a direction that leads me to believe that besides this force arising from the hygrometric nature of the ring, they possess in their structure individually hygroscopic properties, and are capable, like the *Geranium* and others, of moving and taking a definite direction by the loss of moisture.

The above instances, though numerous others might be selected, give illustrations of the action of the evaporation causing the separation of parts, opening of valves, and the expansion of various organs of plants, but it happens in the species of *Epilobium* and *Œnothera*, that moisture performs the same part. In these it will be found that tissues having different contractile powers are opposed to each other as before, but in the reverse method to that which has been described.

Such are sufficient examples to prove that wherever change of position or form occurs by moisture or dryness, there is some peculiar structure of the part; — the tissues having different hygroscopic properties, and these tissues so arranged as to be antagonists to each other. For if there were not this antagonism, the parts being composed only of one tissue of uniform density, there would be merely shrivelling in length or thickness, and we should never find spiral or curved portions in any organ occurring from loss of moisture. Whilst these several parts are young, no displacement occurs, the balance of this power in the tissues being preserved, but as soon as the equilibrium is disturbed, then the effects before mentioned ensue.

To account for these actions consequent on the hygroscopic properties the theory of *endosmose* has been brought forward, which is ingenious, and would be satisfactory if the arrangement of parts were always in accordance with that theory; when dryness performs the duty, we should expect the dense tissue to be on the *reverse side of the curve to which it is found.*

If we examine the section of the valve of *Cerastium*, it is seen that the most dense tissue is on the concave surface, the same in *Geranium:* yet the application of moisture straightens these organs instead of increasing the curve; consequently endosmose will not explain the phenomenon in all instances.

When in those organs which, by loss of moisture, have the concavity of the curve on the side where the tissue is most dense, one of two circumstances must happen in producing it: — 1. Either that the natural condition of the dense tissue is elastic, and having a tendency of its own to bend, and when not opposed by a counteracting force

(as by the looser being charged with fluid), it then coils as a spring—or in the other case, by both tissues losing their moisture, the denser contracts the most forcibly and the curve is toward that side where it is placed. By the addition of moisture the elasticity of the denser is destroyed, and the filling of the cells of the looser restores the equilibrium and the parts regain their natural position.

When we consider the nature of this power,—its various degrees from being barely perceptible until it alarms us by the violence of its reports, and reflect what its effects are and in what parts of plants it is generally to be observed, which will be the most frequent in the organs of reproduction; one is almost led to believe it to be a power given to plants, which is in some measure the representative of the muscular system in animals: for if in plants we discover any change of place of an entire plant, or of any organ, so as to alter its position or remove it completely from the parent, though it is but a feeble act of locomotion, yet it is performed by this power, and almost the whole of the numerous means of promoting the escape of seeds from the seed-vessel depend on the separation of the parts by means of their peculiarly adapted structures.

Besides these properties there can be no doubt that this same power is employed under vital agency, in regulating elasticity, expansion of flowers, opening of the anthers for the dispersion of the pollen, and other functions which are hidden from our examination.

The marked effects which have been mentioned are only a few that have been selected on account of the instances being so well known, but others are to be found with the greatest frequency; scarcely can a plant be examined in which these actions are not evident in some parts of its structure; each of which forms but another instance of the wisdom and intelligence displayed in the structure and contrivances exhibited in the vegetable creation.

VI. — *On the Keratose or Horny Sponges of Commerce.*

By James Scott Bowerbank, F.G.S., &c.

Read January 27, 1841.

Until the publication of the valuable papers by Dr. Grant in the 'Edinburgh New Philosophical Journal' for 1827, but very little can be said to have been known of the true structure and functions of the sponge tribe. In the descriptions there given of the examination of numerous British species, the learned Professor has not only made us intimately acquainted with their general forms and structure, but he has developed the mode of their propagation, and shown it to approximate so nearly to that of the coral tribe, as to leave but little reasonable doubt of the truth of their animal nature. I will not repeat the evidences of the author to establish these facts, as the papers containing the proofs are so easily accessible. It will be sufficient to observe that he has proved that the whole of these poriferous animals are composed of a minute reticulated structure, which derives its support from a thread whose structure is either horny or cartilaginous, hence called keratose; or from the dispersion through its substance of numerous siliceous or calcareous spicula. Accordingly as each of these modes of structure prevails, the sponges are divided into various genera, and among these there is one which contains the sponges of commerce and other keratose species, which are said to consist of tubular horny fibres, and to be destitute of spicula. It is this tribe that I purpose making the subject of this communication.

The investigations of Dr. Grant were in a great measure confined to those orders of sponges which contain in great abundance either calcareous or siliceous spicula: of these the only known British species (*Spongia pulchella*) has been published by Sowerby in the 'British Miscellany,' as occurring on the southern and western coasts of England. Dr. Fleming, in his 'British Animals,' p. 524, has thus described the genus *Spongia*: — "Porous, the cartilaginous skeleton simple, or destitute of earthy spicula."

I was induced to investigate this tribe in consequence of having recently received from my friend Rupert Kirk, Esq., of Sydney, Australia, about forty species of various genera of sponges, among which were many exhibiting every appearance of being true keratose sponges, and which, on a superficial examination, might reasonably have been expected to be destitute of spicula, but upon examining small

fragments of them with a power of 300 linear, I was much surprised to find many of them with well developed spicula embedded in the centre of the horny fibres; and on extending my observations to other species, I found that there were few or none of these keratose sponges in which spicula were not to be detected in some of the fibres; although it often required a considerable degree of patient research to find them, and very frequently the first intimation of their presence in the sponge, was only to be obtained by burning, comparatively, a considerable mass before the blow-pipe, subjecting the ash to the action of dilute muriatic acid, and then examining the residue. But in all cases where their presence was thus detected they were afterwards by patient investigation found *in situ*.

From the results of the examination of the Australian species I was naturally led to suspect that siliceous spicula might possibly be detected in the sponges of commerce; and that I might investigate them as nearly in their natural state as circumstances would permit, I applied to a large importer of sponges, who very kindly supplied me with the species and varieties of the sponges of commerce, before they had undergone the usual process of cleaning and bleaching.

The principal sources for the supply of the European market with sponge is the Mediterranean and the West India islands, and especially the Bahamas. The former is of a finer texture than the latter, and is designated Turkey sponge. Upon carefully examining a considerable number of specimens of this description with the microscope, I found two well-marked species. The West Indian sponge also proved to be a species distinct from either of the Turkey ones.

The two species of Turkey sponge are so similar in external character as to render it impossible to distinguish them from each other by a superficial examination; but in their anatomical structure there is a distinct and very striking difference. The common form — the *Spongia officinalis* of Lamarck—is so familiar to every one as to render a lengthened description of its external characters unnecessary; but it must be remarked that in the state in which we usually receive it, it has been carefully cleaned by maceration in water or a weak solution of acid, from all remains of the mucous or fleshy coating of the horny fibre; and if we examine a fragment of such a specimen beneath the microscope, we shall perceive the fibres to be totally free from all remains of this fleshy coat, and in this state it has the appearance of a smooth light amber-coloured fibre: but if we examine a specimen which has not been thus treated, the thread, especially that of the interior of the sponge, is seen to be coated with a thin and

somewhat rugose film containing minute granulations, the whole being of a darker colour than the mass of the fibre, as represented in fig. 1, Pl. iii. which exhibits a portion of the fibre of *Spongia officinalis* deprived of its mucilaginous or fleshy coat, and fig. 2, which represents a fibre upon which it has been retained; and also in fig. 14, which is from a fibre of the West Indian species.

It is probable that these granules are the incipient gemmules of the sponge, for in some instances I have found pellucid circular bodies, containing a central nucleus, embedded in a fine membrane that coated the fibre. There is much difficulty in finding these bodies *in situ*, in consequence of their great transparency, but when the membrane happens to have been disturbed and partially removed they become very apparent, and present the appearance represented in fig. 3, Pl. iii. when viewed with a power of 1000 linear. When these nucleated bodies were observed upon the fibre, the granulated appearance seen in fig. 2, Pl. iii. was not apparent, and as the nucleated bodies are considerably larger than the granulations, there is a great degree of probability that they are the gemmules of the sponge in an advanced stage of their development.

I am not aware that any author has described the gemmules of the keratose sponges, but those of numerous species of *Halichondria* have been so minutely examined and described by Dr. Grant in the 'Edinburgh New Philosophical Journal,' and they agree in their general character with the bodies under consideration, so closely, as to leave but little doubt in my own mind that they are really the gemmules of the sponge in one of their earliest stages of development; but this is a question which cannot be satisfactorily determined without an examination of the living sponges under the most favorable circumstances.

The greater part of the fibres consists of cylindrical transparent threads, frequently anastomosing, and varying very considerably in their size. This portion of the tissue is destitute of spicula; but there often occur, dispersed amid this form of tissue, large flattened fibres running in a straight direction, and not anastomosing so frequently as the surrounding cylindrical threads; and it is in this portion of the tissue that the spicula are found, embedded in its centre, as represented in fig. 1 *a*, Pl. iii.

Sometimes there is only a single spiculum embedded in the centre of the fibre, while at others two, and occasionally three or more, are grouped together, and here and there one will project a third or half its length from the side of the fibre.

The spicula vary very considerably in their size and proportions,

some of them being slender, much elongated, and terminating acutely, while others are short, thick, and terminating at both ends abruptly in a point. The central cavity in all the forms is distinctly to be seen, (Pl. iii. fig. 4—9). These varieties in form of the spicula are most conveniently obtained by burning small fragments of the sponge before the blow-pipe, and treating the ashes with diluted muriatic acid. All the authors, I believe, who have hitherto treated of this sponge, have described the fibre as consisting of a series of horny tubes. Probably this error has arisen in the first place from their great transparency, and secondly from the want of microscopical combinations that would admit of their being examined in such a manner as to allow of their true nature being discovered. For it is only by a careful examination of their structure as opaque objects, by the aid of a Lieberkuhn, and with a power of about 500 linear, that the solidity of the fibre can be exhibited with certainty. This examination is much facilitated if a small mass of sponge be tied firmly round with thread, so as to compress it into the form of a cylinder; and then if a section at right angles to its axis be made with a sharp knife, the transverse sections of the fibres will be readily seen, presenting exactly the same appearance that we observe in a similar section of any somewhat softened horny substance. The face of each section is covered with parallel streaks or lines, occasioned by the passage of the knife, but not the slightest appearance of a central orifice can be detected, and the results are precisely the same, whether the specimen under examination be dry or saturated with water; (Pl. iii. fig. 10). It is somewhat singular that in the latter case, when the fibre was supplied with water while beneath the object-glass, it did not present any sensible increase of substance or the slightest variation in form. Upon examining in the same manner the second species of Turkey sponge, and the West Indian species from two localities, the results were precisely the same, —not a single tubular fibre could be detected in any of the numerous specimens subjected to examination.

If we examine fragments of these sponges as transparent objects, with the same amount of microscopic power (500 linear), we never observe any partial injections of air in the interior of the fibre, which would certainly be the case if they were composed of tubular instead of solid threads.

The second species of Turkey sponge, as I have before stated, is so similar in its form and external characters to *Spongia officinalis*, as to render it difficult, if not impossible, to distinguish one from the other without the aid of high microscopic powers; but immediately we sub-

ject them to this test, the difference becomes at once apparent. The mode of arrangement and size of the fibre of the new species is very similar to that of the former one, and the large irregularly formed tissue containing spicula occurs as frequently as in *Sp. officinalis*. The striking character in this species is its possession of a beautiful vascular tissue, which surrounds, in great abundance, nearly every fibre of its structure; which, when it is immersed in water and viewed as a transparent object with a power of 500 linear, presents the appearance represented at figs. 11 and 12 Pl. iii. where the vessels are seen meandering over the surface of the fibres in every direction. Sometimes they proceed for a considerable distance in a line nearly parallel to the axis of the fibre, giving off frequent lateral branches at right angles, some of which terminate immediately in cœca, while others embrace half or two thirds of the diameter of the fibre before they terminate; other branches thus given off continue their course for a considerable distance, either running parallel to the parent vessel, or passing in spiral lines round and round the fibre; the direction of the spire sometimes being from right to left, and at others from left to right. Occasionally they expand to twice their original diameter, and again contract to their former size. This beautiful tissue is not imbedded in the horny mass of the fibre, but is contained in a sheath, which closely embraces it, and it frequently occurs in the preparation of a fragment of the sponge for examination, that the horny fibre is withdrawn from this sheath, leaving it in the form of a thin membranous tube, in the substance of which the vascular tissue is imbedded. Fragments of the vascular coat are also often seen partly adhering to the fibre from which they have been torn. The vessels are completely imbedded in the sheath which contains them, as no projection of their surface appears when they pass round the fibre. It might at the first view be imagined that they were merely excavations or canals in the substance of the sheath surrounding the horny fibre, but this is proved not to be the case, by their often being torn out from the substance in which they are imbedded, and exhibited as a detached network. So in like manner it might be thought they were but a tissue of solid fibres imbedded in the outer coat of the structure; but their tubular character is established by the frequent occurrence of alternations of air and water within their cavities. Little doubt therefore can remain of their being a true vascular tissue, destined to perform an important office in the economy of the animal during its life.* In one instance

* Since this paper was read, my friend Mr. G. Busk, of the Dreadnought Hospital

(Pl. iii. fig. 12, *a*) I observed in some of the vessels numerous minute globules, exhibiting every appearance of being globules of circulation analogous to those found in the blood of the higher classes of animals. They are circular, and vary in size from each other to about the same extent that the blood-discs in man and animals do. The largest of these globules was $\frac{1}{16666}$ of an inch in diameter, the smallest $\frac{1}{50000}$ of an inch. The mean diameter of the vessels was $\frac{1}{9340}$ of an inch; and the fibre of the sponge upon which they ran was $\frac{1}{588}$ of an inch in diameter.

A similar vascular tissue exists in a considerable number of the keratose sponges from Sydney; in some it is as distinctly apparent as in the Turkey sponge (as in fig. 13), while in others, although equally abundant, it is scarcely to be distinguished from the horny mass of the fibre. In some of the Australian species, where it is extremely well developed, the centre of the horny fibre abounds in spicula. In some specimens of *Spongia officinalis* also, there are faint traces of a similar tissue occasionally to be seen. Upon making sections of small cylindrical bundles of the Australian species, in the manner before described, and viewing them as opaque objects with a power of 500 linear, and with the aid of a Lieberkuhn, they proved to be of as solid a texture as the sponges of commerce: no indication of a cavity existing in the fibre being apparent, excepting where spicula had been formerly imbedded, and which had been displaced by the passage of the knife. The only truly tubular sponge that I have yet seen is *Spongia fistularis*, described by Dr. Grant in one of his papers in the 'Edinburgh New Philosophical Journal.' I am indebted to the learned Professor for a specimen of this interesting species, he having kindly shared with me the few remaining fibres in his possession. Upon examining these, immersed in water, with a power of 500 linear, I found the interior of the horny filaments to be truly tubular. The filaments, unlike those examined by Dr. Grant, were quite empty, no dark granular matter being visible; and in several of them I saw the air gradually expelled by the entrance of the water, thus proving the truth of their tubular nature beyond a doubt. I cannot take leave of this subject without a few observations on the nature of the spicula which are found in such abundance in these curious bodies.

Professor Grant, in his 'Outlines of Comparative Anatomy,' p. 5,

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Ship, whose skill in the injection of fine vascular tissues is so well known, has succeeded in filling these minute vessels with coloured pigments, in the most complete and satisfactory manner.

says — "The skeletons of poriferous animals consist of separate minute, earthy, crystalline spicula, connected together by a condensed, elastic, cellular substance; or of tubular elastic filaments of a horny consistence. These parts are developed internally through the whole cellular tissue of the body, and are often protruded through the surface to protect the pores or the large vents. The earthy spicula in most of these animals are siliceous, in many they are calcareous, and, like the horny filaments of other species, they appear to be tubular, like many natural crystals." Professor Rymer Jones, in his 'General Outlines of the Animal Kingdom,' p. 14, says,—"Crystallized spicula of this description form a feature in the structure of the sponge which is common to many vegetables, resembling the formations called raphides by botanical writers."

I am not aware of the existence of any true crystals which naturally present a central orifice similar to that of the general mass of the spicula of sponges. The normal characters of a true crystallized body appear to me to be solidity and angularity; while, on the contrary, the prevailing form of the earthy deposits in the animal kingdom is that of the hollow cylinder. In this respect, therefore, the spicula of sponges, whether they consist of siliceous or calcareous materials, always present themselves in the shape of a true cylinder, or of some modification of that form. In further confirmation of the probability of their animal origin, it may be stated that when siliceous spicula are exposed for a considerable length of time to the action of the blow-pipe, and then examined with a power of 500 linear, it is usually apparent that the internal tubular cavities of the spicula are coated with a film of carbonaceous matter, strongly indicating the existence of a thin coating of animal substance within the spicula, (Pl. iii. fig. 4—9). The external surfaces of the spicula also frequently exhibit a carbonaceous filmy coat when incineration has not been continued too long, which gives them the appearance of having been covered with a thin film analogous to the periosteum of true bone.

The raphides, in many instances where I have had the opportunity of observing them, have presented a truly crystallized and angular form. They are solid, and, in no case that I have observed, cylindrical like the spicula of sponges. Nor do these curious bodies occupy the same relative situation in the plant that the spicula do in the sponge. The latter are truly a portion of the organization of the animal, while the former can be considered but as a secretion deposited in the cellular or inter-cellular structures of the plant. Under this view, therefore, they cannot be adduced as a link connecting the

sponges with the vegetable kingdom. It is also worthy of observation that the normal form of the spicula of sponges is the same, whether they be composed of silex or carbonate of lime, which would still further seem to indicate that they were truly an animal deposit; and indeed Dr. Grant, in a subsequent sentence in the same page of his 'Outlines of Comparative Anatomy' that was before quoted, says — "they are formed from materials due to the vital energies of the animals, and they form normal and necessary parts of its structure, like the solid skeletons of higher animals."

The solidity of the fibre of the sponges of commerce, and of the whole of the keratose species from Australia that I have examined, will render it necessary that *Spongia fistularis* should be removed from this groupe, and I therefore beg to suggest the propriety of making it the type of a new genus to be denominated *Fistularia;* and this is the more necessary, as, among the fossil sponges, tubular species are found in very considerable numbers.

VII. — *The process of charring Vegetable Tissue as applied to the examination of the Stomata in the Epidermis of Garden Rhubarb.* By the Rev. J. B. Reade, M.A., F.R.S.

Read July 21, 1841.

Since I first suggested the process of charring vegetable tissues, with a view to a more accurate knowledge of their structure, I have had many opportunities of observing the advantages of its application. The well-defined form and peculiar character of the cells of cellular tissue, especially when the cellules are reticulated; the inner and separable membrane of spiral vessels, as in the *Acrocomia aculeata;* the external position of the spiral thread with respect to this membrane; and the undoubted existence of spiral vessels in the roots of many dicotyledonous plants;—these are among the more interesting examples of the success of the experiment.

It is my present intention to do myself the honor of communicating to the Microscopical Society, the result of a recent application of this process to the epidermis of the leaf-sheath or *ochrea* of the common garden rhubarb. A flower-stalk of this plant, with its beautiful and well-known series of involved sheaths, out of which the clusters of flowers and their basal leaves successively emerge, so entirely loses the naturally strong adhesion between the subjacent cellular tissue and the epidermis, if it be placed for a few days in water, that this investing membrane may be readily separated by the finger from the inner surface of the sheaths. Portions of this delicate tissue, of considerable size, translucent and colourless, may thus be obtained in a fit state for microscopical investigation.

The first thing which is noticed upon examining this tissue in its natural condition, a little water only being placed between the glasses to prevent the loss of light consequent upon the inner reflections from the surfaces of the glass, is the beautiful development of the *stomata* and their surrounding concentric layers of green molecules. The number of these *stomata* in a square inch is about 6000. They are of an oval form, having, in the larger examples, a major axis of $\frac{1}{400}$ of an inch, and a minor axis of about half that length.

Stomata are described by Professor Lindley as "passages through the cuticle, having the appearance of an oval space, in the centre of which is a slit that opens or closes according to circumstances." But it is added,—"there is, perhaps, nothing in the structure of

plants upon which more different opinions have been formed than these stomates." Professor Lindley himself, for instance, supported by Decandolle, Adolphe Brongniart and Link, recognizes them as openings. Other anatomists of high reputation entertain a directly opposite opinion, and deny the existence of passages. Dr. Brown describes them as glands, really almost always imperforate, with a disk formed by a membrane of greater or less opaqueness. It would doubtless be great presumption in me to say that the opinions of all these eminent observers are wrong; nevertheless, I cannot say, with the example of the rhubarb before me, that any one is exactly right. Those who deny, *in toto*, the existence of apertures, or suspect the openings to be an optical deception, are unquestionably in error. Professor Lindley seems almost to doubt whether Dr. Brown has sufficiently established the existence of the membrane overlying the apertures; and Dr. Brown makes the perforations the exception, and not the rule. One thing, however, is clear, from this contrariety of opinion, that the ordinary mode of microscopic examination, which has led so many naturalists to different and opposite conclusions, must fail in the case before us. And indeed, the fact is, that the tissue in question is of so delicate a nature that an observer might be pardoned if he either considered the supposed openings to be spaces more pellucid than the surrounding tissues, or if he confessed at once, with the celebrated Grew, that he had no exact idea of their structure.

The application of the process of charring will be found to throw great light upon the whole subject. From its very nature it will act upon the vegetable tissue, but upon that only; and will consequently discover, with the utmost exactness, every the most minute perforation. At the same time it will not fail to enable us to detect the most delicate portion, and the precise position and character of this naturally colourless membrane. Accordingly, the examples which will be submitted to actual inspection—"*oculis subjecta fidelibus*," will establish the following facts:—

That in the simple uncharred state of the semitransparent tissue there is much room for difference of opinion, so that the eye, fortified by a little previous theory, might most pardonably see the *stomata* either open or closed.

That the application of the process of charring proves, beyond a doubt, that the *stomata* in this tissue of the rhubarb are distinct openings into the hollow chambers of the parenchyma of the leaf.

That the perforation is the rule and not the exception in the structure.

And that the exception, where it exists, *i. e.* where the *stomata* are closed, proves the existence of the overlying membrane discovered and described by Dr. Brown.

This last fact, indeed, is very satisfactorily established. The membrane alluded to, though in some cases wholly absent, yet in others it slightly projects beyond and along the margin of the apertures, it is sometimes partially extended quite across, and again, as a delicate *tympanum*, it wholly overlies the *stomata*.

I venture to submit these few observations, under the impression that a successful investigation of the functions of elementary organs must be preceded by an accurate knowledge of their structure.

Stone Vicarage,
Aylesbury, May 25, 1841.

Postscript to The Rev. J. B. Reade's paper "On the process of charring Vegetable Tissue, as applied to the Stomata in the Epidermis of Garden Rhubarb." By the Rev. J. B. Reade.

Some ingenious experiments by Dr. Williams, communicated to the Microscopical Society last August, appear to lead to the conclusion that the process of charring vegetable tissue is of very doubtful efficacy in determining delicate structure. With respect to the *stomata* in question, he is led to infer that their overlying membrane, though having, under the application of this process, every appearance of a continuation of the epidermis, is *really* nothing more than an inspissation of gelatinous mucus, raised by the heat into contact with the glass, and, by the mere accident of pressure, extending as a carbonized pellicle from one edge of the aperture to the other.

That much caution is necessary in the application of red heat to a delicate and almost imperceptible tissue must be conceded at once, and it is certainly far from unreasonable to call in question the results of such agency. In the present case, however, a very few words of explanation will convince those who are interested in this enquiry, that the process of charring not only enables us to say, in every instance, whether a given *stoma* is open or closed; but, with reference to the point in dispute, it assists us *in detecting the structure* which determines the character of the membrane.

The charred specimen which illustrates these few remarks was first of all immersed in alcohol, distilled water, and dilute hydrochloric

acid. When perfectly dry it was carefully examined under a high power, and the membrane, which we are not to forget was originally discovered by Dr. Brown *without the application of heat*, appeared distinctly organized, extending along and beyond the margin of the *stoma*, and uniting, almost after the manner of *lips*, in the enclosed oval space.

These *labia*, where they existed, became more evident after the process of charring; which process, in the particular example now alluded to, was so conducted as to obviate all error arising from pressure. The tissue was placed on a slip of glass, and submitted to the action of heat, *without* being covered by another slip. Thus both the supposed sources of error are avoided; the one, by the previous removal of organic mucus; and the other by a different manipulation.

Mr. Lens Aldous has furnished me with a sketch of these membranous *labia* of the stomata under the direction of Mr. Bowerbank, (Pl. i. fig. 3). The power employed was about 2000 linear; and I may be permitted to add that Dr. Williams, after seeing the membrane under this power, immediately approved of the process which rendered it so distinctly visible.

Stone Vicarage,
November 20, 1841.

VIII. — *On the Anatomy of four species of Entozoa belonging to the genus Strongylus, from the Delphinus phocœna, or common Porpoise.* By JOHN QUEKETT, Secretary to the Microscopical Society.

Read August 18th, 1841.

THE subjects of the present paper, with one exception, were all found in the lungs of the porpoise. Two of them have been long known and described by Rudolphi, Klein and others, under the names of *Strongylus inflexus* and *minor;* a third, from the circumstance of its being found in company with the *inflexus*, has, by many observers, and by Rudolphi particularly, been considered as a younger specimen of that species; whilst the fourth appears hitherto either to have escaped notice, or else to have been confounded with the last. My examinations of this Entozoon lead me to consider it as a distinct species; and from certain peculiarities presently to be noticed, I have named it *Strongylus invaginatus.* The first one which I shall describe is the *Strongylus inflexus*, the largest of the four; it occurred most abundantly in the bronchial tubes, and in such numbers as almost to close them up, but many specimens were found in the right ventricle and auricle of the heart, and in the principal blood-vessels of the lungs as well.

All the specimens invariably presented their tails towards the larynx, and the males were readily distinguished from the females by their bodies tapering away gradually and then becoming slightly expanded at the extremity; the females, on the contrary, were nearly of equal size throughout, and their tails were provided with two inflected points or hooks, from which the name *inflexus* appears to have been derived, (Pl. iv. fig. 1). The average length of the male is about seven inches, whilst that of the female is nine inches. When alive both sexes were of a dirty white colour, and the alimentary canal, which was filled with black matter, was readily discernible through their transparent muscular tunic. The males were much more slender than the females; the head of each was rather blunt, and provided with an orbicular mouth, with which the alimentary canal was continuous, (fig. 17). In some specimens this tube was filled with black matter up to the mouth, in others it was empty for the first half inch or more. The intestine in many of them passed in a straight line from the head to the tail, in others it proceeded in a wavy course, and its contents were very cohesive, and when examined microscopically were found

to consist of very minute black granules, mixed with others much larger and of a fatty nature. The caudal extremity of the male (fig. 2) was slightly expanded, and terminated in two horn-like processes, one on either side, with smaller horns or spines projecting from them, (fig. 2, *a*) ; these and the terminal half inch of the animal were invested with a thin transparent and flattened membrane, (fig. 2), similar in shape but much larger than that represented by fig. 12 as belonging to *Strongylus minor:* some striæ were observable on its inner margin, (fig. 2, *b b*). When placed in spirit this membrane became opaque. Striæ proceeding in a parallel direction from the sides of the worm to the median line, at an angle of 45°, were observable on the last half inch of this extremity of the animal.

In the females, which were not only larger but darker than the males, the genital apparatus (fig. 3) was readily discernible through the abdominal parietes. It occupied about the lower two thirds of the animal, and consisted of two parts precisely alike ; each one commenced about the upper third of the body by a pointed process, which gradually increased in size for the space of an inch, (fig. 3, *a*) ; this space may be termed the ovarium: it then became contracted suddenly into a small duct, which was about three lines in length, and corresponds to the oviduct or Fallopian tube (fig. 3, *b*), which opens into the last portion or uterus (fig. 3, *c*), which is upwards of three inches in length, and presents a series of contractions and dilatations for the first two inches (fig. 3, *d*), which gives it a nodulated appearance; for the last inch these nodes disappear, and both uteri ultimately unite together and terminate in the small hook by a delicate opening, (fig. 3, *e*).

The alimentary canal is straight throughout its whole length ; it runs between the two uteri to the largest hook, at the side of which it opens externally. In all the females examined the ovaria were full of ova, and they presented these interesting peculiarities. In the upper part of the ovarium the contents consisted principally of minute cells or granules, which were larger and more developed towards the oviduct. In the oviduct the granules had almost assumed the form of ova, in the uterus perfect ova were found; those taken from the upper part were full of vitelline globules (fig. 4), whilst those examined lower down, in some cases were more opaque in one part than another, and going still lower, the granules were observed to be fewer in number but rather increased in size (fig. 5), and the oval figure in which they were arranged was disturbed (fig. 6), they had disappeared and probably had become absorbed at one point (fig. 7). In examining

them when taken from a part nearer the end of the uterus, the disappearance of the granules was still more marked, and the form of the future worm could now be made out, (fig. 8): when arrived at this point of development the young in the interior of the ovum could be traced progressively until they were perfectly formed (fig. 9), and when slight pressure was made on the lower end of the Entozoon the young escaped readily at the uterine aperture, and were quite lively even after the porpoise from which they were taken had been dead a week. The ova were about $\frac{1}{50}$ of an inch in length and very easily ruptured, especially those which contained the young perfectly developed. In every female the transition from the vitelline globules to the perfect worm was to be seen.

The next species was found in common with the last, being twisted together in a knot around them, both in the bronchial tubes and blood-vessels. It has been noticed as the young of *Strongylus inflexus*, but on comparing them both together I find that the difference between the two is so marked as to leave no doubt of their being distinct species; and I have since been much pleased to find that the same view of the matter was adopted by Kuhn,* who has described it under the name of *Strongylus convolutus*.

The females are much larger than the males, and both are much inferior in size to the *inflexus*, the one being about two inches in length and the other about an inch and a half. They are of nearly uniform diameter throughout, and their black intestinal canal is very visible through their parietes; in some specimens it took a straight, in others a tortuous course; the head was more pointed than in the *inflexus*, and the commencement of the œsophagus was marked with striæ, (fig. 10). Nothing remarkable was observed in any other part of the body except the tail, which was slightly flattened, and on one side only was provided with a membrane which was continuous with a small semicircular terminal portion, in which were placed three very small horn-like bodies, arranged in a radiated form; in the lower part of the worm two dark curved bodies were placed parallel to each other, which were probably connected with the genital apparatus, (fig. 11 *a*). In the female the genital apparatus was double, as in the last species, but was quite free from the contractions and dilatations; its contents, like those of the *inflexus*, exhibited the gradual transition from vitelline globules to the perfect worm, but in many specimens the disappearance of the globules commenced in the centre, and so went on

* Mémoires du Muséum d'Histoire Naturelle, tome xviii. p. 357.

until a thin margin corresponding to the worm was left. The tail of this Entozoon is represented in fig. 11.

The third species is the smallest of the whole, and from this circumstance has been named *Strongylus minor*, neither the male nor female much exceeding an inch and a quarter in length. It occurred in the venous sinuses of the head and in the cavity of the tympanum, and from living in blood they were of a reddish hue. The females rather exceeded the males in size, and both sexes tapered gradually from the head to the tail, which was much more evident in the male than in the female, in which peculiarity it resembled the male of the *Strongylus inflexus* before noticed. Nothing else remarkable was observed in the male except at the tail (fig. 12), where the membranous investment was thrown into a semicircular fold, and in it three tolerably large horn-like processes, much larger than those of the *convolutus* (fig. 12,*a*), were observed: nearly at the end of the body of the worm there was a dark oval mass, connected either with the genital apparatus or with the intestine, (fig. 12,*b*). In the female the ovarium commenced at the junction of the upper with the middle third of the body. It consisted of two convoluted ducts, which ultimately united into one and terminated on the side of the tail. Ova in different stages of development were observed in all the females of this species, but they were much smaller than in any of the others. The tail of the female is represented at fig. 13.

The fourth species was found in the lungs of the porpoise which I had for dissection on the 9th of last month. On examining minutely the surface of the lung, it was found that its pleuritic investment was raised into little tubercles about the size of a small pea; and on cutting into one of these five very long and slender white worms were drawn out, one being much shorter than the rest, this I subsequently ascertained to be the male. On tearing a portion of the lung, a vast number of these cysts were found imbedded in its substance, and in each one there were several worms coiled up in a very small compass, and the cysts could be readily torn away quite entire from the surrounding tissue with the worms in them. On examining some of these specimens microscopically, I found that it was a distinct species from any of the preceding: it approaches nearest to the *convolutus*, but it differs from this in many points. The males were few in number, and about an inch in length, the female being three inches and sometimes more. Besides this great disparity in size, both sexes were inclosed in a very thin and delicate membrane, which projected from their sides, and made them appear more than as wide again as they really

were, (fig. 14, 15). In the male, around the head, this membrane was thrown into puckers, as represented in fig. 14; immediately below this, on one side, it formed a semicircular fold, and then became parallel to the body of the worm throughout its whole course, until it came to the tail, where again it was slightly puckered, (fig. 15). These folds were more remarkable in the female than in the male, and the only parts of the worm in immediate contact with this membranous sheath were the extremities of the head and tail. Near the tail in the male two curved dark bodies were observed, like those described in the *Strongylus convolutus*, and immediately above them the intestine was slightly enlarged, (fig. 15, *a*). In the female the ovaria were very long and full of ova, like those of the other species, but the external opening of the uterus was seen on the side of the body, near the end, and at this point two small hooks were observed, (fig. 16, *b*). The intestine proceeded a little farther on than the uterus, and terminated where the tail came in contact with the sheath. The manifest differences between this Entozoon and any of the others previously described, alone warrant me in making this a distinct species: and the most striking, and at the same time most constant character, being the investing membrane or sheath, I have given it the name of *invaginatus* at the suggestion of my friend Dr. Willis, in consequence of this peculiarity.* All the authors who have described the genus *Strongylus*, call the membranous investment at the tail both of the male and female, a bursa or sheath for the genital organs; some of them, as Kuhn, describe an intromittent organ; but in these four species I have not seen one protruded, but my friend Mr. Busk has noticed it in a specimen of *Strongylus minor*.

I cannot conclude this paper without alluding to some curious facts which present themselves for our consideration. Entozoa, from the time of their first discovery to the present day, have exhibited more astonishing and wonderful phenomena than any other tribe of animated beings; and perhaps throughout the whole kingdom of Nature no class has been so frequently the subject of opposite opinions, and on the matter of their generation we are now nearly as much in the dark as ever. We have, nevertheless, in the specimens before us, the startling truth of one and the same species of Entozoon living in directly opposite media, viz., in blood and in air; for it has been stated that the *Strongylus inflexus* was found in the bronchial tubes, in the prin-

* By means of a higher power than was used by me, Mr. Busk has found that the sheath may even be seen around the minute animal whilst in ovo.

cipal blood-vessels of the lung, and even in the heart itself; and the venous sinuses at the base of the brain and the cavity of the tympanum were literally clogged with *Strongylus minor*. Now we cannot but imagine that any animal so infested must, as a necessary consequence, have both the functions of respiration and circulation greatly impeded. Three porpoises which I have dissected within the last two months, have all contained Entozoa, and all these were taken in the Thames; and it is probable that this may be the reason of their leaving the ocean and running up the rivers at particular seasons of the year, and it would be curious to ascertain whether those taken at sea about the same period were so infested. Some light, I trust, may be thrown on the occurrence of Entozoa in particular parts of an animal, when we have them, as in this instance, actually living in the blood. We can now readily imagine how the young, when emitted from the parent, can be transported to all parts of the body by means of the circulation, and analogy would lead us to conclude that the blood of other animals may contain Entozoa, as well as that of the porpoise. There is another curious circumstance connected with these *Strongyli*:—all the specimens of the four species just described are nearly constant in their size, we meet with no young ones amongst them; these probably are to be found in parts of the body where the scrutinizing eye of the anatomist has as yet failed in detecting them. But however, this is mere matter of speculation; and I will no longer detain the Society on a subject which, from time immemorial, has been to reflecting minds a wonder, how Entozoa "live, and move, and have their being."

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EXPLANATION OF PLATE IV.

Fig. 1. The tail of the female of *Strongylus inflexus*.
- *a*. Outlet of the alimentary canal.
- *b*. Outlet of the oviduct.

Fig. 2. The tail of the male of *Str. inflexus*.
- *a*. Horn-like processes, with smaller ones projecting from their sides.
- *b b*. Parallel striæ on the expanded membranous investment.

Fig. 3. Female genital apparatus of *Str. inflexus*.
- *a*. Ovarium.
- *b*. Oviduct.
- *c*. Uterus.
- *d*. Moniliform appearance of the uterus.

Fig. 4. Ovum from the upper part of the uterus full of vitelline globules.

Fig. 5. Ovum in which the vitelline globules have diminished in number, but those remaining are much increased in size.

Fig. 6. Ovum showing the disappearance of the globules in one part.

Fig. 7. Ovum exhibiting the same appearance as the last, only more marked.

Fig. 8. Ovum exhibiting the young worm nearly developed.

Fig. 9. Ovum exhibiting the young worm perfectly developed.

Fig. 10. Head of male of *Strongylus convolutus*.

Fig. 11. Tail of male of *Str. convolutus*.
- *a*. Two dark curved bodies near the anal outlet.
- *b*. Three very minute horn-like bodies attached to the small semicircular fold of investing membrane.

Fig. 11a. Head of female of *Str. convolutus*.

Fig. 11b. Tail of female of *Str. convolutus*.

Fig. 12. Tail of male of *Str. minor*.
- *a*. Three horn-like bodies attached to the investing membrane.
- *b*. Dark oval body near the termination of the alimentary canal.

Fig. 13. Tail of female of *Str. minor*.

Fig. 14. Head of male of *Str. invaginatus*.

Fig. 15. Tail of male of *Str. invaginatus*.
- *a*. Two dark curved bodies similar to those in fig. 11 *a*.

Fig. 16. Tail of female of *Str. invaginatus*.
- *b*. Two minute hooks near the vulva.

Fig. 17. Head of male of *Str. inflexus*.

A	represents the average length of the		female, *Str. invaginatus*.
B	"	"	male, *Str. invaginatus*.
C	"	"	male, *Str. convolutus*.
D	"	"	female, *Str. convolutus*.
E	"	"	male, *Str. minor*.
F	"	"	female, *Str. minor*.

IX. — *On the Minute Anatomy of the Larva of Anthomyia canicularis, Meigen.* By Arthur Farre, M.D., F.R.S.

Read April 28, 1841.

The subject of the present memoir has come under my notice as a parasite of the human body, of which, however, it appears to be a rare inhabitant, as I have met with but a single instance of the kind, and I believe there are only two or three similar cases on record.

The mere circumstance however of this insect in its larva state being found in the human intestine, it is not now so much my object to record, as it is to bring before the Society a brief description of the minute anatomy of this singular parasite, with a view of showing the peculiar adaptation of its organs, particularly those of the digestive system, to the circumstances in which it is thus occasionally placed.

The insect considered as a parasite appears to have its parallel in the *Œstrus* or *bot* of the horse and sheep, and may perhaps be considered as constituting the bot of the human subject, though it does not appear to be altogether limited to man, but has been also observed to occur in the *Boa constrictor*.*

The case which afforded me the opportunity of making the following observations was that of a rather sickly child, a girl 5 years of age, who was brought as an out-patient to St. Bartholomew's Hospital, in the month of June, 1837, having the ordinary symptoms of irritation produced by worms, for which a brisk purgative was prescribed. This had the effect of bringing away a vast quantity of the parasites, which were stated to be alive at the time they were passed, and were described by the parent of the child as coming away by handfuls at a time, and which continued to be passed at intervals for three weeks, when the case was lost sight of.

A similar case occurred to Dr. Haviland of Cambridge, in the year 1836, in the person of a clergyman 70 years of age, who, after suffering disagreeable sensations about the epigastrium, which he described as a tremulous motion, accompanied by loss of appetite and general weakness, passed in the summer and autumn of the same year very large quantities of the larvæ, and, according to his own statement, the chamber-vessel was sometimes half full, and he thinks that alto-

* See Lancet, vol. ii. 1839-40, p. 638.

gether he must have passed several quarts: they were alive, and continued to be passed for several months. This case is recorded by the Rev. Leonard Jenyns, in the 'Transactions of the Entomological Society,' vol. ii. part 3, and is accompanied by a very accurate figure of the insect. A rather rude drawing of evidently the same insect also accompanies a paper by Dr. Bateman in the seventh volume of the 'Edinburgh Medical and Surgical Journal,' p. 48, on the subject of larvæ found in the human body; while a much older, though more accurate one, will be found in Swammerdam's 'Bibl. Nat.' tab. 38, figs. 3 & 4. And lastly may be mentioned a case published in the 2nd volume of the 'Memoirs of the Medical Society of London,' which appears to be of a similar kind. These are the only cases that I find recorded of the occurrence of the larva in the human subject, but it has also been observed in the *Boa constrictor*, as appears from an instance recorded by Mr. Iliff, to which I have just alluded, and where the larvæ were passed along with the masses of urate of ammonia which constitute the excrement of that animal.

There appears to be little doubt that in all these cases the insect is the same, and that it is the larva of the *Anthomyia canicularis* of Meigen, or *Musca canicularis* of Linnæus.

Its minute anatomy does not appear to have been investigated, and it is this deficiency which I shall attempt to supply from my notes of the dissection of the specimens obtained from the first case to which I alluded.*

The larva (Pl. v. fig. 1, *d*) is five lines in length by one and a half in breadth. It is of a dull brown or blackish brown colour, soft and flexible, but having a tough integument, which however is sufficiently transparent to allow of the alimentary canal being seen through it. The body consists of eleven segments, but the last is apparently formed of three blended into one, (figs. 2 & 3). Each segment carries a pair of feathery branchial appendages, which project at right angles from the body, constituting a double row on either side. There is also a double row of small eminences extending down the dorsal surface, but the abdominal surface is nearly smooth. The lateral appendages, (fig. 4), of which the upper series is much larger than the lower, are pinnate. The central shaft of these, which is long and pointed, is hollow, and communicates apparently with the tracheæ. The lateral pinnæ are again pinnated on their outer margin. The

* For a specimen of this larva consult the Museum of the Royal College of Surgeons, London; Cat. Nat. Hist. Series, pt. iv. No. 609, D.

integument, (fig. 5), which appears smooth to the naked eye, is found when examined under the microscope, to be granulated all over with minute dentiform or pointed processes, which appear to be of a harder nature than the rest of the tegument, and resemble on a small scale the spinous prominences in the tegument of certain cartilaginous fishes, as the sturgeon; and it appears to be only an extraordinary development of these latter processes which constitutes the long feathery lateral appendages already described.

The mouth of this larva is perhaps the most interesting part of its anatomy. The head (fig. 6) is furnished with two broad fleshy lips, (*a a*) which together constitute a broad disk, having in its centre a minute aperture (*b*) leading to the œsophagus, and flanked on either side by the hook-shaped mandibles, the sharp points of which are directed downwards and somewhat outwards, (*c c*) and are nearly retracted each within a separate sheath, the aperture in the extremity of which just allows their points to protrude. Each of these broad fleshy lips is crossed by transverse parallel plaits or folds of membrane, about twenty-five in number, which in their free margin exhibit a delicately notched appearance, and in fact in every particular resemble a similar structure which is seen on a larger scale in the sucking disk situated upon the dorsum of the head of the *Remora*, by which that fish is enabled to attach itself firmly to various objects. In the present instance, however, the structure, though precisely similar, is exceedingly delicate, and so minute as to be invisible to the naked eye, though there can be no doubt that it is intended to answer the same purpose in both. For by the aid of this sucker the larva is enabled to fix the head, so as the more readily to insert its sharp hook-shaped mandibles into the soft mucous membrane of the intestine which it inhabits, and draw therefrom its nutrient juices, which would thus readily flow into the little aperture of the mouth, situated in the centre between the mandibles, assisted also by the partial vacuum which would thus be produced during the act of adhesion.

The mandibles are sunk so deep between the two fleshy lips, having only the points projecting from the aperture of their investing sheaths, that it is necessary to disconnect them entirely from the soft parts before they can be accurately examined. They are placed parallel to each other, with their hooked points directed downwards, so as the more readily to be inserted. The mandibular apparatus (fig. 7, *a*, and fig. 8) on each side consists of three portions. The first portion is hooked and sharp pointed, (fig. 8, *a*) and is only the $\frac{1}{60}$ of an inch in length. It is nevertheless furnished at its base with a delicately

shaped ball, adapted accurately to a socket in the second joint, and has projecting from either side of its base a sharp spine or trochanter, for the insertion of the tendons of the abductor and adductor muscles by which its movements are effected. The second joint (fig. 8, *b*) bears the socket to which the ball of the first is adapted, and at its opposite extremity is united to the third and principal portion of the jaws, (fig. 8 *c*), which consists of a broad expanded corneous plate, of less density than the preceding, and resembling in form and office a similar structure well known as occupying the centre of the large claw of the lobster, being for the attachment of the muscles by which the mandibular hooks are moved to and fro. The whole mandibular apparatus measures about the $\frac{1}{16}$ of an inch in length, and, being very firm and solid, presents a remarkable contrast in texture to the surrounding soft parts with which it is connected, and from which it is easily detached.

If the body of the insect be laid open the alimentary canal is seen to be of considerable length, and much convoluted, (figs. 9 & 10). It commences by an exceedingly delicate hair-like œsophagus, (fig. 7, *b*), so narrow that it would appear to be specially destined to transmit fluid nourishment, and nothing else. This terminates about the third segment of the body in a minute globular cavity or proventriculus, (fig. 7, *c*), which is of the same diameter as the rest of the alimentary canal, and immediately below which four very short salivary vessels enter, (fig. 7, *d d d d*). From this point commences the large intestiniform stomach, (fig. 10, *a a*), which after contracting in its first third to the finest thread, (fig. 10, *b*), again dilates and proceeds of uniform diameter to the point where the four slender biliary vessels enter, (fig. 10, *c*), where it again contracts and forms a short intestine. The whole alimentary canal is about six times the length of the body, and of this length the stomach forms about five-sixths. Its greatest diameter does not exceed one-third of a line, and its least is that of a mere thread. The whole structure appears to be that of an animal adapted to live on fluid nourishment.

The principal external openings to the tracheæ appear to be two apertures situated on the dorsum of the last segment of the body, and which constitute the last pair of the series of dorsal eminences formerly noticed. These apertures correspond with the very remarkable and conspicuous pair of organs occupying a similar situation in the last segment of the œstrus of the sheep, and which are also the external openings of the respiratory apparatus in that insect.

None of the insects were alive when they came into my possession,

and they were placed in spirit of wine for the purpose of preserving them previously to their being dissected. Several days after my attention had thus been directed to the subject, I happened to observe at the bottom of a jug of New-River water a small living object, which appeared very much to resemble the larvæ which I had recently been examining; and upon placing this under the microscope I found the resemblance to be complete, except that the animal was only about two-thirds the size of the former. It was deficient also in the pinnæ upon the lateral spines, which were simple, but the mandibular apparatus was perfectly formed. On making further search two other individuals of the same species were found in different stages of growth; the smallest, however, not exceeding one-third of a line in length, though still possessing some of the characters of the larger ones. One of these specimens was very lively, moving freely at the bottom of the water, and frequently protruding and retracting its proboscis, by which it dragged itself along.

This fact is a matter of some interest, as furnishing a clew to the source of these parasites, since it is evident that the larvæ can pass along the water-pipes which supply the metropolis, and may thus be swallowed in the water used for food: and in the present case the larvæ, or the ova, must have traversed a distance of at least a mile. At the same time it is evident that this cannot always afford an explanation of their mode of entrance into the body, because in the case of the clergyman at Cambridge it is expressly stated that "he never drank water unmixed, but generally beer, tea," and the like; at the same time the water used for these beverages was entirely supplied from a pond on a stiff clay. If therefore the ova found entrance with the fluid aliments, they must have withstood the action of heat, as in making the beer, tea, &c.; while on the other hand it is difficult to suppose that they passed in with the solid food, because the larvæ are evidently aquatic. Perhaps the most inexplicable part of the case is, the fact of their occurrence in such immense numbers. In the Cambridge case several quarts were passed in a few months, and in the instance which I have just recorded they were described as coming away by handfuls. It is extremely difficult to account for this fact, because a number of larvæ, or their ova, must have been swallowed equal to those which were evacuated, since they could not multiply by generation in the alimentary canal, they being in the larva state, and having, as the dissection showed, and as is well known in the case of larvæ, the generative organs undeveloped; indeed no trace of generative organs was visible: while it is difficult to suppose

that the parent animal could have been accidentally swallowed, and its ova, previously impregnated, have become developed in the bowels; though this is perhaps the least objectionable supposition. At any rate the parent animal could not live in the alimentary canal, since the larva has been recognised by several entomologists as being that of a well-known fly, (the *Anthomyia canicularis*). The latter supposition however which I have advanced, namely, that the fly, having its eggs previously impregnated, may have been swallowed, and thus, perishing in the digestive canal, have left the ova unencumbered, and in a possible situation for development, derives some countenance from the circumstance of the extreme rarity of the occurrence of these larvæ as parasites, there being, as I have mentioned, very few cases on record; which would give to the circumstance the air of an accidental occurrence, of which however it is again immediately robbed when we contemplate the singular and very obvious adaptation of its organization to the peculiar circumstances in which it is thus placed. The anatomy being clearly that of an animal destined, or at least adapted, to live by adhesion and suction on fluid nourishment, though it is clear from the fact of some being found nearly two-thirds grown in simple river water, that the larva is also capable of life and growth in other elements than the contents of the alimentary canal, and in other capacities apparently than that of a parasite.

Much, it appears, may be advanced on either side, and indeed the whole subject appears to me to be calculated to afford interesting points for discussion; and it is chiefly with this view that I have brought it before the notice of the Society.

EXPLANATION OF PLATE V.

Fig. 1. *a, b, c, d.* Larvæ of natural size, in different stages. The three first from the New-River water; the fourth from the intestine.

Figs. 2 & 3. The same amplified five diameters; 2 dorsal, 3 ventral aspect.

Fig. 4. One of the upper series of branchial appendages.

Fig. 5. Portion of tegument of the back.

Fig. 6. Head. *a a.* Two plaited lobes forming the suctorious disk. *b.* Mouth. *c c.* Points of the mandibles just exserted from their sheaths. The remaining portion of mandibles seen indistinctly through the semitransparent flesh.

Fig. 7. Mandibular apparatus and upper portion of alimentary canal. *a.* Mandibles. *b.* Œsophagus. *c.* Proventriculus. *d d.* Salivary tubes. *e.* Commencement of stomach.

Fig. 8. Two views of the mandibles. *a.* First portion, sharp pointed at its extremity, and showing two trochanters at its base for insertion of adductor and abductor muscles, and bearing a ball adapted to socket in *b*, the second joint. *c.* Third portion for origin of muscles.

Fig. 9. Larva (natural size) opened to show alimentary canal.

Fig. 10. Ditto. *a a.* Intestiniform stomach. *b.* Contracted portion. *c.* Point where biliary vessels enter.

X. *Observations on the Structure of Bats' Hair.* By JOHN QUEKETT, Secretary to the Microscopical Society.

Read October 20, 1841.

OF the endless variety of beautiful objects disclosed to us by means of the microscope, the hairs of different animals are not amongst the least interesting, and of these none excel in beauty of structure those of the bat tribe. It is to some peculiarities observable in the structure of the hair of these curious animals that I would direct the attention of the Society for a short time this evening. In order to make the subject more intelligible to those who may not be familiar with the formation and growth of hair, these few explanatory remarks may not perhaps be out of place. "Hair," says Mr. Hunter, "is of two kinds respecting its growth. One is that which grows continually, or has the power of growing continually if not allowed to grow to its whole extent, or when allowed to grow to its full extent, although it then becomes stationary, yet is capable of growing when cut. The second kind grows until it arrives at its full extent, and then cut or not cut it must be shed, and, like feathers, must be replaced by another growth. Most animals have both sorts, but man I believe has only the first. The tail and mane of the horse are of the first kind, whilst the hair which covers the body is of the second."*

It is to hair of the second class that my observations will be principally directed. According to physiologists hair is developed in highly vascular sacs or follicles, situated in the cutis or true skin, and each hair commences at the bottom of the follicle by a swelling, termed the root or bulb: this is softer than the rest of the hair, and is hollow, and contains within it the pulp of the hair, which is probably a vascular prolongation of the bottom of the follicle; and each hair is formed by the successive aggregation of cytoblasts or new cells, and is gradually protruded from the follicle, both by the growth and elongation of its constituent cytoblasts and by the addition of new layers of these to its base, the apex and shaft of the hair being formed before the bulb, just as the crown of a tooth is before its fang.

The cytoblasts are round and loose at the base of the hair, but are more compressed and elongated in the shaft; and by this rectilinear arrangement the hair assumes a fibrous character.

* Hunterian Manuscript Catalogue.

Having stated thus much on the growth of hair, I shall proceed at once to the examination of that of the bat tribe: of sixteen species of these animals, the hairs of which I have examined, all were analogous in structure to one or other of the forms represented in Plate 7, figs. 7, 8, 9, 10, &c. They are characterized by the shaft presenting at intervals peculiar raised markings, which are arranged sometimes transversely, at others obliquely, to the axis of the hair; in some specimens they project a considerable distance from the general surface, and the true shaft of the hair appears between them at certain intervals. Having on more than one occasion failed in pulling the hairs out of the skin with my fingers, in order to obtain some a knife was used, and the hair held firmly between its edge and the thumb: on examination of these hairs afterwards it was found that they were altered in character, the markings on them, which were so peculiar, being destroyed in some parts and left undisturbed in others; they appeared as if something had been taken away from them in certain points. This led me to expect that the curious surfaces which these hairs present might be owing to a development of scales on their exterior, and repeated examination has convinced me of the truth of this supposition. I have since found that by submitting hair to a scraping process, minute scale-like bodies, tolerably constant as far as regards their size and figure, can be procured, so that bat's hair may be said to consist of a shaft invested with scales, which are developed to a greater or less degree, and vary in the mode of their arrangement in the different species of the animal. The surface of that part of the hair nearest the bulb is nearly free from any trace of scale, (fig. 7, *a*) but as we proceed towards the apex the scaly character becomes more evident. In many hairs the scales lie in a direction at right angles with the shaft, and one scale forms a complete band around the shaft (fig. 6); in others they run with varying degrees of obliquity, giving a true spiral character to the hair (fig. 9); whilst in many others scales may be seen in all stages of development (fig. 10). The larger kind of hairs, such as are procured from the various species of vampire, are generally of a dark yellow colour, and are comparatively smooth externally, but exhibit a cellular structure internally. The scales may be readily procured for examination by scraping the hair, whilst still adherent to the skin, with a knife, in a direction from the apex towards the bulb; or, when separate, by laying them on the glass on which they are to be mounted, keeping them steady either with the finger or another piece of glass, and passing a knife along them. A more simple plan still may be had recourse to, which is

merely to lay the hair on a slip of glass, then, having breathed upon it, press another glass upon it three or four times in succession, which will cause the scales to be detached in small quantities, and become adherent to the glass. In all cases, if possible, the hair should have been first washed with ether, which will remove much of the greasy matter with which most hairs abound.

Many of the scales are not unlike in shape those from the wings of butterflies, but are much more minute, and exhibit no trace of striæ on their surfaces (fig. 11); but those taken from dark-coloured hairs have the colouring matter deposited upon them in small patches (fig. 12). In some cases they appear to terminate in a pointed process, like the quill observed in butterflies' scales; and in others the free margin is serrated (fig. 13). By scraping many of them will be detached separately, but in some few cases as many as four or five will be found joined together (fig. 14): in the larger hairs the cellular structure of the interior, as well as the fibrous character of the shaft, can be well seen when the scales have been removed (fig. 15). The difference (in appearance) of the hair near the bulb where it is smooth, and towards the apex where it is scaly, besides proving that the scales must grow after the shaft has appeared above the cuticle, points out the analogy between this part of a hair and the quill of a feather; and it would follow that the addition of new matter at the base alone would not account for the after growth of the scales: it would seem more probable that the view of the subject entertained by Dr. Mandl and Mr. Busk* was the more correct, viz.—that the hair has a vitality of its own, independently as it were of the bulb,—in fact, a kind of circulation; and by this means the scales on its surface grow, and continue to grow after the hair has appeared above the cuticle. If there were not this deficiency of scales at the base of the hair, the shaft being tightly embraced by the neck of the follicle, the scales from their position would certainly be an obstacle to the easy passage of the hair above the skin. It would be an interesting subject for examination to take the hair of a very young animal, and measure the distance of the scales from one another, and their length, and to notice as the animal grew whether there was any increase in their size, and whether they became more distant from each other: as far as my observations have gone they lead me to believe that the smaller the hair is in diameter the more closely packed are the scales; and it would account at once for some appearances

* Microscopic Journal, vol. i. p. 26.

which many hairs present, viz. such as are represented in figs. 16 & 17, if it were found that the shaft of the hair grew faster than the scales which surround it, and that the whorls of scales were separated from each other just as the slides are in the drawing out of a telescope.

Since these observations were made I have been kindly favoured by Mr. Powell with some hair of a bat from India, the species of which is at present unknown, in which the view I have entertained of the nature of bats' hair is beautifully borne out, and if any doubt had previously existed of the scaly character, I think that it would at once be banished when these hairs were seen under the microscope. The scales are most remarkably developed, and in some of the hairs they surround the shaft in a continuous whorl; and without any preparation by scraping, in many places they will be found to be entirely wanting (fig. 18), whilst in others they are still attached to the shaft, but out of their proper position (fig. 18, *a*).

Physiologists have been long agreed that hair and feathers are constituted upon one uniform plan, but as yet there have been many links wanting to complete the chain of evidence upon which this analogy is maintained. The hair of the animals in question will certainly supply the links to a certain extent, and as the zoologist would tell us that they resemble quadrupeds principally in their mode of reproduction, and birds in their mode of progression, so the microscopic observer now can say that they resemble both in the structure of their hair.

EXPLANATION OF PART OF PLATE VII.

Fig. 7. A bat's hair, showing the absence of the scales at the root.

Fig. 8. Portion of another hair, in which the scales are placed nearly at right angles with the shaft.

Fig. 9. Another specimen, in which the scales are placed obliquely.

Fig. 10. A specimen in which the scales are smaller, and only extend round a portion of the circumference.

Fig. 11. Scales removed from a bat's hair, of a light colour.

Fig. 12. Scales from a dark hair, exhibiting the pigment.

Fig. 13. Scales removed from the hair of the Indian bat, which are beautifully serrated at their upper margins.

a. Outside view of the scale.

b. Inside view.

Fig. 14. A number of scales closely connected together.

Fig. 15. Hair of a species of Vampire, in which the scales are very evident at the upper part; at the lower they have been scraped off, and the cellular interior of the hair is exhibited.

Fig. 16. A small hair of the Indian bat, showing the pointed extremity, and the close manner in which the scales are arranged.

Fig. 17. A hair of the same bat, exhibiting the whorls of scales more distant from each other, and the smallness of the shaft between them.

Fig. 18. A similar specimen, from which the scales have been removed in certain parts.

a. A scale lying detached from the hair.

XI. — *On three species of Sponge containing some new Forms of Organization.* By James Scott Bowerbank, F.G.S., &c.

Read November 24, 1841.

In the course of the last session of the Microscopical Society, I had the honor of reading a paper descriptive of the occurrence of siliceous spicula in the keratose sponges of commerce, in which they had not before been supposed to exist. I also described, in the same paper, the existence of a vascular system surrounding the fibres of certain sponges of the same class, and other peculiarities of structure, which I trust will have an influence in determining the true position which these singular creatures occupy in the animal kingdom, and in some measure assist future observers in dividing them into such natural groups as may render them easily recognized by the student. Hitherto the modes of arrangement resorted to by naturalists have been anything but satisfactory, from the distinctive characters being taken, almost entirely, from their external form, and the aspect and condition of their skeletons in the dry state. Such a mode of proceeding is evidently insufficient for the attainment of a correct knowledge of species, and among these animals especially, whose anatomical details require the application of the highest microscopical powers that even at this period are at our command, before we can attain a correct and satisfactory idea of their minute and complicated structures. The classification and mutual relation of the species of the higher orders of animals, have long been determined by the peculiarities and coincidence of their anatomical structure; and until the same principles are systematically extended to the obscure and difficult tribe of the Spongiadæ, I am convinced it will be in vain to expect such a classification of these protean forms as will admit of their being recognized and studied by naturalists with the same degree of facility that obtains in other branches of Natural History. It is with the hope therefore of contributing something towards the attainment of this desirable end, that I again introduce the Spongiadæ to the Society, for the purpose of describing some peculiarities in the structure of three species that have escaped the observation of previous writers on these subjects.

The first of these is a native of our own seas, and has not I believe been hitherto described by any author. In the present state of arrangement of the British sponges, as published by Dr. Fleming in

his 'History of British Animals,' it must be referred to the genus *Halichondria*, and I have given it the specific name of *Johnstonia*, in honor of Dr. Johnston of Berwick-on-Tweed, whose 'History of British Zoophytes' is so well and so favorably known to the public, and who has a 'History of British Sponges' nearly ready for publication.

Plate VI. fig. 1.

*Halichondria** *Johnstonia*.—Sessile, massive, surface undulating. Terminations of the excurrent canals disposed on the most elevated parts of the surface, depressed, sometimes bounded by a slightly elevated marginal ring. Incurrent canals inconspicuous. Colour of the crust slate-grey, of the interior substance yellow. Spicula of the skeleton mostly simple and slightly curved, rarely attenuating towards their ends, but usually of equal diameter throughout their whole length, having hemispherical terminations; sometimes, but rarely, tri-radiate or multi-radiate. Spicula of the flesh minute, stellate; rays attenuating regularly to their apices. Spicula of the crust minute, simple and fusiform, having their surfaces irregularly tuberculated, and their terminations very obtuse.

This sponge is found attached to the Thatcher and other rocks, in the neighbourhood of Torquay, about low water-mark. The parts of the crust which are most exposed are of a dark grey colour, sometimes almost approaching to black; while the marginal portion near the base is frequently of a light grey, and occasionally almost white. The crust varies from about a quarter to half a line in thickness. The interior substance is of a dull yellow colour, firm in texture, and very much resembling the crumb of bread in appearance. It is traversed by numerous large excurrent canals, of about the tenth of an inch in diameter, which pass in a tortuous direction from the base of the sponge to the most elevated parts of its surface, where they ter-

* Since this paper was read at the Microscopical Society, I have consulted with my friend Dr. Johnston of Berwick-on-Tweed, upon the propriety of making this species the type of a new genus; and from the well-marked difference in structure that exists between it and and the most characteristic species of *Halichondria*, it has been thought advisable that it should be separated from the latter. I have therefore named it *Pachymatisma*, from παχυς, *densus*, and ιματισμος, *vestitus*, and the following are the characters adopted :—

Spongia carnosa, crustacea, nec cellulosa nec vi resiliendi prædita, cute crassâ lævi osculis sparsis perforatis obsita; spiculis siliceis et aciculiformis et stellatis sparsis et gemmulis siliceis ubiquè commixtis referta.

minate in depressed areas, which are sometimes surrounded by slightly elevated marginal rings. These ventral orifices are frequently disposed in parallel lines, which occupy the summits of the ridges that intervene between the depressed parts of its surface.

The great variety that exists in the form of the spicula of this species is very remarkable. The most common is a simple slightly curved cylindrical spiculum, of equal diameter throughout its whole length, with hemispherical terminations, as represented at fig. 6, *a*. Occasionally, but not very frequently, there is a single spiculum to be seen, in which there is a gradual attenuation towards one end, but in all the cases that I have observed of this description it does not terminate acutely, but as in the normal form, hemispherically. Among the common forms there are frequently to be observed large tri-radiate and irregularly branched spicula, which have the radii usually terminating in a simple point, but they are sometimes bi-furcated, as represented at fig. 5, *a*. The remaining figures of this group (figs. 3 & 4) represent some of the varieties of these forms which were drawn by the camera lucida, with a power of 100 linear. The central cavities are distinctly visible in all these spicula, (fig. 8) and in the compound ones there is a free communication between all their parts. In some of the spicula the cavity is much larger than in others, and it may be observed with great advantage if a small piece of the sponge is burned to a white ash in the flame of a lamp, and then mounted in Canada balsam. The transparent membrane lining the interior of the spicula is converted by this means into an opaque carbonaceous film, which becomes distinctly visible to the observer. If the fleshy substance of the sponge be examined by transmitted light, with a power of 500 linear, another description of this organ presents itself, which is also very remarkable, in the form of minute stellate spicula, the rays varying in number from three to ten or twelve, passing off from a common centre in every direction. The radii are gradually attenuated from their bases towards their points, and terminate acutely. Four of these spicula, which were sketched from the camera lucida with a power of 450 linear, are represented at fig. 2. These singular spicula abound in every part of the yellow fleshy matter of the sponge, in which they are disposed without any definite arrangement.

If a thin slice be taken from the outer surface of the crust of the sponge, and examined as a transparent object with a power of about 300 linear, short fusiform spicula with very abrupt terminations will be observed. They are thickly dispersed throughout the whole of the encrusted surface, but without any apparent order of disposition. —

Upon submitting them to examination with a power of 900 linear, their surfaces were observed to be irregularly tuberculated, as at fig. 7, where three of them are seen attached to a fragment of one of the larger spicula of the skeleton, after having been separated by incineration from the animal matter that surrounded them. These little spicula, from their great abundance in the encrusted surface of the sponge, are justly entitled to be distinguished as the spicula of the crust. They are found occasionally, but comparatively rarely, along with the stellate spicula of the fleshy substance, and they occur also thinly dispersed beneath the surface of the great excurrent canals.

I did not succeed in detecting any organization in the epidermal membrane of the crust, probably in consequence of its being obscured by the great abundance of minute spicula immediately beneath its surface; but in the membrane lining the excurrent canals, there were numerous minute vessels or fibres, disposed in parallel lines, in one part of the tissue, while at another spot they assumed the form of an irregular reticulation. These vessels or fibres are exceedingly minute, and it is requisite that they should be observed with a power of at least 800 linear, and then it is only in the clearest and most transparent parts of the membrane that they are likely to be seen.

The gemmules of this sponge are dispersed, in great abundance, throughout every part of its substance. They are of an oval form, their longest diameter being the $\frac{1}{217}$ and their shortest the $\frac{1}{194}$ of an inch. They vary considerably in size, but the above are their average dimensions. When seen by direct light, with a power of 100 linear, they appear of the same colour as the surrounding fleshy matter; but when viewed as transparent objects, they assume an iron or slate grey colour and are nearly opaque, having their surfaces closely studded with minute papillæ, which are produced by the projection of the points of numerous small spicula, which are enclosed in the crust or shell of the gemmule, and are disposed in lines radiating from the centre to the circumference of its body. The forms of these minute spicula are exceedingly various, but the best developed ones appear conical, having their bases towards the centre of the gemmule, and their apices slightly elevating the parts of the outer integument immediately above them.

The mode of disposition of these spicula is best observed when a small portion of the sponge has either been treated with boiling nitric acid or by incineration in the flame of a lamp. The dissolution of the gemmules is not effected by either of these agents; and to view them with the greatest effect they should be gently triturated with a little

water between two pieces of glass, until some of them are broken into small pieces. In these fragments the spicula may be seen *in situ*, arranged in the manner I have before described, and cemented together by siliceous matter, which appears to abound in the outer integument of the gemmule. Upon measuring some of these minute spicula *in situ*, I found their average length to be $\frac{1}{3570}$ of an inch, or about equivalent to the diameter of a disk of human blood; and their average diameter $\frac{1}{28570}$ of an inch: so that they are of exceeding minuteness as compared with those found in the other parts of the same animal. The rays of the stellate spicula (fig. 2) average $\frac{1}{1000}$ of an inch in length by $\frac{1}{7900}$ in diameter, and those of the skeleton have a diameter of about $\frac{1}{1250}$ of an inch.

My friend Mr. C. G. White, of Poplar, to whom I gave a fragment of this sponge, observed a circumstance attending the structure of the ovoid bodies that had previously escaped my observation. Upon examining some of them which had been deprived of their fleshy integuments, with a very high power, he found that they were frequently furnished with a small pore or funnel-shaped orifice, situated about midway between the two smaller extremities. The discovery of this pore is an interesting circumstance, as it is a strong additional proof of their gemmular nature. Link and Raspail, in treating of *Spongilla friabilis*, describe a small yellow spot as existing on the outer tunic of the gemmular bodies of the sponge; and M. Gervais, in his observations on that species, describes the same organ and the manner in which the sponge is propagated by the escape of granular bodies through an orifice which exists at this spot.

In the encrusted surface of this sponge I also observed numerous round siliceous molecules, which were dispersed amid the spicula of that part in abundance. The diameters of these, in many cases, were equal to that of the surrounding spicula, but the greater number did not exceed the half or a third of that size.

The curious stellate spicula of the flesh are probably among the earliest indications of the production of true bone in the higher class of animals, in which we find it formed, in the plates of the skull and other lamellated bones, from distinct centres of ossification; the origin of each being a few stellate fibres or spicules, which are continually produced from their centres outwards until they approach each other, and, coalescing, form one uniform bony surface. In the crustaceous and fleshy surfaces of some tunicated molluscs, we find an abundance of minute stellate spicula of carbonate of lime; and on the surfaces of the bones of some cartilaginous fishes, we find a thin filmy stratum of

bony structure, which is composed of numerous minute centres of ossification, touching each other at their extreme points, and leaving numerous small spaces unoccupied by the bony structure, so that the whole surface assumes a beautifully checquered appearance when examined as a transparent object with a power of about 100 linear.

The sponges which I have now to describe are exceedingly anomalous in their structure, especially the first of the two, which I received, with many others, from my friend Rupert Kirk, Esq., of Sydney, Australia; who procured it from the coast at Wollongong, about forty miles from Sydney. Hitherto we have found that where silex has been the material with which the skeleton of the sponge tribe has been strengthened and supported, that earth has always been presented to us as a true animal secretion, either in the shape of spicula of various forms, or of very minute spherical molecules; but in these species, although in great abundance, it is decidedly of extraneous origin, consisting of numerous grains of sand built into the substance of the fibrous skeleton of the animal, without any definite arrangement: the whole being surrounded externally by a coating of the cartilaginous or horny matter of which the foundation of the skeleton is constructed, and with which we are so familiar in the sponges of commerce. We are acquainted with many instances in which extraneous substances are employed externally to assist as a covering or defence; as among the Mollusca, by *Trochus agglutinans*, which attaches to the external surface of the shell the small shells and fragments of bivalves or any other substance that suits its purpose. We observe also among the aquatic larvæ, that the cases in which they pass so great a portion of their existence, are, in many species, most ingeniously and beautifully built up of fragments of small stems of plants, bits of shells and other materials; and in *Sabella Belgica*, so common on our own coasts, the animal resides in an elongated conical tube, which is constructed, in the most symmetrical and beautiful manner, of grains of sand cemented together by a strong cartilaginous or horny matter; but in no instance that I am aware of have we found the animal skeleton formed from extraneous materials, as in this curious and new form of sponge.

DUSEIDEIA,* Johnston, MSS.

(Plate vi. fig. 9).

D. Kirkii. Sessile, massive, somewhat compressed. Skeleton

* The following are the characters established by my friend Dr. Johnston for this

coarsely fibrous and coralloid in appearance, having numerous grains of sand separately imbedded in its substance, the whole being enveloped by the horny matter of the fibre. Spicula rare, short, slightly curved, terminating somewhat obtusely.

The base of this specimen has been destroyed by the action it has apparently undergone among the shingle; but its position is well marked by the concentration of its fibres at the point at which, from its form and other circumstances, we might expect it to have been placed, and there is no indication whatever of its ever having been pedunculated. The form is somewhat fan-shaped or compressed, one side being regular and nearly flat, while the other has a protuberant mass upon its surface. The fibres of the skeleton are coarse and rigid, assuming the direction of aberrant lines, radiating from the base of the animal, and anastomosing with each other in every direction by means of small lateral branches; thus forming a coarse and rigid but somewhat regular reticulated skeleton. The large fibres frequently attain the size of half a line in diameter. If we place a few of these fibres in Canada balsam between two slips of glass, and examine them by transmitted light with a lens of about half an inch focus, we shall readily perceive numerous grains of sand imbedded in the substance; and if the examination be continued with a microscopical power of about 200 linear, it will be seen that the grains are not imbedded in the fibre from pressure through the external surface, but that they occupy its very centre, and are externally enveloped by a thick coating of the cartilaginous substance of the animal, (fig. 10). In this condition they do not occupy the interior of a central cavity, but are regularly built together, with a slight space intervening between each grain, which is filled with dense cartilaginous matter, thus firmly cementing the whole into a compact body, while at the same time each grain of sand may be said to occupy its own cell. The mode in which this curious building process appears to be achieved is this. After the cartilaginous matter has entirely enveloped the grain of sand at the extremity of a projecting fibre, there is an accumulation of its

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genus: — Spongia multiformis sessilis crassè cellulosa mucagine sabulo arenatâ scatens, sicc friabilis, fibris imperfectis seposita: spiculis sparsis paucis formâ et magnitudine incertis.

In the Synopsis Spongiarum et Lithophytorum, at the end of the 'History of British Sponges and Lithophytes,' the author has altered the name from Duseideia to Dysidea.

substance which at once offers an adhesive surface to which the next grain that may happen to come in contact with it becomes attached; this is gradually enveloped by the cartilaginous substance, and the same process is repeated until, grain by grain, the whole of the fibre is constructed. Sometimes it happens that after the envelopment of the last, no other grain comes in contact with the termination of the fibre for some time, in this case the cartilaginous substance is projected in the form of a dense yellow thread, the point of which attaches itself, like a sucker, to the surface of the first grain of sand with which it comes in contact, and in this manner numerous single grains may be seen, each supported, as it were, upon a pedestal. In some of these cases the point of attachment scarcely exceeds in diameter that of the pedestal, while in others the grain has a third, a half or two thirds of its surface enveloped by the spreading tissue. In some of the most slender fibres there is but a single row of grains, while in others of large diameter they are aggregated so closely and in such numbers as to comprise four or five in a single line of diameter. At the spaces intervening between the grains the animal matter is sufficiently dense to render it at all times exceedingly obvious, but it is frequently so thinly spread over the surface of the sand as to render it difficult to distinguish between it and the siliceous matter beneath, without rendering it opaque by charring it between glasses over the flame of a lamp; but in this state, and immersed in Canada balsam, the thinnest pellicle covering the grains becomes visible when viewed with a power of about 200 linear.

The grains of sand are usually arranged in the fibre of the sponge in as close and regular a manner as they are in the case of *Sabella Belgica*, but with this difference; in the latter the cementing medium is a beautiful cellular tissue, which spreads only so far over the outer surface of each grain as to securely fix it in its place, and in this state appears like a thin regularly reticulated membrane; while in the sponge the cementing medium is the cartilaginous substance of the sponge, and which, however thin it may be, covers the entire surface of the grains of sand.

Spicula are of rare occurrence in this sponge. Occasionally two or three are seen grouped together, but usually solitary spicula occur at a considerable distance from each other, imbedded in the exterior coating of cartilaginous matter. They are comparatively short and thick in proportion to their length, and decrease very slightly from the middle to near the points, which are terminated acutely but somewhat abruptly.

DUSEIDEIA FRAGILIS, Johnston.

Spongia fragilis, Montague.

(Plate vi. fig. 11).

Duseideia fragilis. Form massive, variable, sessile. Surface exasperated, of a dull ochreous yellow colour. Excurrent canals few, large. Fibre of the skeleton rigid, coarsely reticulated, rugose, with numerous grains of sand imbedded in their substance, or tubular, with few or no grains imbedded in their structure.

Spicula of the skeleton variable in size and form, imbedded within or attached to the outer surface of the fibre.

This species is the *Spongia fragilis* of Montague, who has described and figured it in his paper on British sponges, published in the first volume of the 'Memoirs of the Wernerian Society.' The specific description of that author is as follows.—"*Spongia fragilis.* Fragile, friable, coarsely reticulated; the fibres rugose, as if covered with minute sand." The figure, although coarsely executed, is characteristic, and is evidently that of the skeleton only; and from the subsequent portions of the description it would appear that the author had seen no other specimen than the one he describes.

The specimen represented by figure 11, I found attached to the Thatcher rock, near Torquay; and it was undoubtedly alive when I removed it from the rock. I have since procured numerous specimens from among the sea-weeds cast up on the beach at Brighton, the greater portion merely skeletons, but others were in various stages of decomposition, and some few in a sufficiently fresh and perfect state to allow of their being proved to be the same species as the Torquay specimen. Under these circumstances I have thought it advisable to add to and somewhat modify the original description of Montague, but I have adhered to it as closely as possible. Thus Montague has described it as fragile, while, in the majority of cases, the fibre is comparatively strong and rigid, from the great quantity of sand imbedded within it. He has also described it as friable, but as this character applies only to the skeleton in the dry state, it is better omitted as unnatural. The form of this species is exceedingly variable. In its young state, as represented in figure 11, it is spread over the surface to which it is attached, as if it were a coating sponge; but when fully developed it rises to the height of two or three inches, and has a tendency to assume a thickened fan-shaped or compressed form; and the base is usually twice or thrice as long as it is broad, as if this were the natural mode of its development.

It is of a dull ochreous yellow colour, and has the surface much asperated by the projection of numerous stout sandy fibres. The excurrent canals are large and few in number, and have their terminations occasionally projected beyond the surface. The fibre of this species varies considerably in its character. The larger and coarser portion is constructed of grains of sand of various sizes, encysted separately in the substance of the horny structure, as described in the preceding part of this paper in treating of the structure of *Duseideia Kirkii*. Among the arenaceous fibres there are others of a fistulose structure, which have few or none of the grains of sand imbedded in them. In the largest of the arenaceous fibres the grains of sand are accumulated in such numbers, and so closely built together, as frequently to render the fibre nearly impervious to light, as represented at figure 12; but in the smaller ones, as seen in fig. 13, they are few in number, and disposed in nearly the centre of the fibre. A few spicula are occasionally found imbedded among the grains of sand or attached to the surface of the fibre, as represented at figures 12 and 13. The tubular fibres are smaller than the arenaceous ones, but originate from them and freely anastomose with them. The fistulose cavity is large, continuous, and contains an abundance of spicula of a variety of sizes and forms. In the smallest of these fibres the spicula are usually lying in a longitudinal direction; but in the larger ones they are disposed without any apparent order, and assume every possible direction. Sometimes the small tubular fibres suddenly expand to twice or thrice their original diameter, and again contract to their former size, the cavity expanding in proportion, and containing a great accumulation of spicula; at other times the tube becomes attenuated, and terminates by attaching itself to a grain of sand, of eight or ten times its own diameter, around which it spreads its horny structure until the grain is entirely enveloped by it, and firmly supported as it were upon a pedestal. These isolated grains are probably but the first stones in the foundation of the future large arenaceous fibres. Occasionally we find a few small grains of sand imbedded in or attached to the external surface of the fistulose fibres, and then the spicula are fewer in number in their immediate neighbourhood, but usually they are without grains of sand. These fibres also appear to be destined to perform another important office in the economy of the animal; for in many of the Brighton specimens of this sponge I observed ova or gemmules, of various sizes, imbedded in the parietes of the tubes; some of them projecting from the inner surfaces towards the centre of the fistulose cavity, but the greater number were projected from the

outer surface of the fibre in all degrees short of absolute separation. When viewed as transparent objects with a power of 300 linear, these gemmular bodies appear to have a large opaque nucleus, of a somewhat granulated character, which fills the whole of its interior, and is surrounded by a thin horny-looking shell or coat. The spicula are exceedingly variable in size and form; the greater portion of them are slightly curved and attenuated towards each end, terminating in some acutely and in others somewhat obtusely, (Pl. vii. fig. 1); others have their bases elliptical or globular, as in figures 2 and 3; occasionally, though much more rarely, we observe them furnished with numerous spines or tubercles, as represented by fig. 4; and still more rarely they are multiradiate and of great comparative size, as represented at fig. 5. Two other spicula of an exceedingly curious form were also observed; the shaft of the spiculum being curved and the terminations recurved, to such an extent as to form a large hook at each extremity, as represented at fig. 6. I could not detect any peculiar form of spiculum in the fleshy substance which fills the interstices of the skeleton; but I observed imbedded in its substance one or two detached spicula of the form represented by fig. 1. This fleshy matter is of a firm consistency, and has dispersed throughout its substance numerous round or oval bodies, varying from $\frac{1}{3000}$ to the $\frac{1}{4000}$ of an inch in diameter, containing usually one, but sometimes two nuclei. These bodies are nearly uniform in their colour and general aspect, and present every appearance of being the cytoblasts whence the cellular substance of the animal is derived.

The results arising from the peculiarities in the structure of the sponges which I have just described, are calculated in some measure to modify the present arrangement of the Spongiadæ, as published by Dr. Fleming in his 'History of British Animals.' The occurrence of triradiate and multiradiate siliceous spicula in the species first described, and these forms having also been found in the Australian keratose sponge which I published in a short paper in the 'Annals and Magazine of Natural History,' vol vii., will render these compound forms of spicula of comparatively little value as generic characters applied to either the siliceous or to the calcareous sponges; but their occurrence may perhaps hereafter form useful specific characters. The other two singular and striking forms, the stellate and the fusiform spicula represented by figs. 2 & 7 (Pl. vi.), are each characteristic of a particular part of the animal; the first belonging to the fleshy substance, while the second is indicative of the epidermis and its inflexions through the numerous canals. In another British species of sponge which I have recently

examined, I found stellate spicula imbedded sparingly in the interstitial fleshy matter of the animal, which were strikingly different from those in the corresponding structure of *Halichondria Johnstonia;* and in the same sponge I found a very minute variety of stellate spicula in the skin or crust, in place of the fusiform ones observed in the crust of *H. Johnstonia.* The peculiar and characteristic forms of these organs, which appear, within certain limits, to be constant to their separate types, not only in each species, but in each separate part of the same species, strongly indicate the necessity of searching for our specific characters in the minute anatomical characters of the animal, rather than in the vague and changeable characters afforded by external form and general aspect; and I have but little doubt that when we have sufficiently matured our knowledge of their anatomical structure, many species, and especially that now under consideration, will be removed from their present situations, and become the types of new and well-defined genera.

The extraordinary structure exhibited in the arenaceous fibres of the skeleton of the two sponges last described, will probably lead to the establishment of an entirely new division in the order; and a second new division will most probably be hereafter founded on the structure of the new and very curious sponge *Dictyochalix pumiceus,* described by Mr. Stutchbury of the Bristol Institution, at the last meeting of the Zoological Society. In this sponge the whole of the fibrous skeleton is composed of silex, so transparent, that it has the appearance of being formed of spun glass. These, I repeat, will probably be some of the results arising out of the present and similar investigations of the numerous members of the sponge tribe; but at the present period our knowledge of the curious and beautiful tissues that are already known, and those that will, without doubt, be hereafter found to exist, is comparatively so slender as to render it expedient to refrain from systematizing, until we attain a more complete knowledge of the details of their anatomy.

Of these organs the spicula especially require a careful re-examination and classification. Dr. Grant, in his laborious and valuable papers on "The Structure and Functions of the Sponge," in vol. xiv. of the 'Edinburgh Philosophical Journal,' and in vols. i. and ii. of the new series of the same work, has minutely and accurately described a considerable number of forms that occur in British species; but however numerous the forms may appear that he has there described and figured, they are in reality but few compared with the number that yet remain unfigured and undescribed.

Other authors have written on these subjects since the publication of Dr. Grant's papers, but none in so lucid and so effectual a manner: and unfortunately one of the most celebrated of these has done much more to retard than to advance our knowledge of these subjects. I allude to Raspail, who, in his papers on *Spongilla friabilis*, published in the 'Mémoires de la Société d'Histoire Naturelle,' 1828, labours very hard to prove Dr. Grant in error, in having described the spicula of *Spongilla*, and some other sponges treated of in his papers in the 'Edinburgh Philosophical Journal,' as cylindrical bodies; and endeavours to prove them to be vegetable crystals or raphides, and of a hexagonal form: and figures them as such in Plate xxii. figs. 5 and 6 of the Mémoires, as seen without immersion in water, while at fig. 4 a spiculum immersed in water is represented, which presents precisely the natural appearance, and agrees exactly with the description of Dr. Grant. The singular perversion of Raspail's ideas on this subject, can only be accounted for on the supposition that he did not take into account the great amount of spherical aberration that inevitably ensues when the rays of light pass through transparent cylindrical bodies of high refractive powers. From the great celebrity of Raspail as an observer and a writer, it becomes the more necessary that these errors should be noted: and it is but justice to Dr. Grant to state that I have followed him to a considerable extent in his observations on *Spongilla friabilis* and many other species of which he has treated, and I can bear testimony to the truth, accuracy, and acuteness of observation displayed in his laborious and valuable contributions to science.

EXPLANATION OF PLATE VI.

Fig. 1. *Pachymatisma Johnstonia.*

Fig. 2. Stellate spicula, occurring in the fleshy substance of *Pachymatisma Johnstonia.*

Figs. 3 & 4. Two varieties of spicula of *Pachymatisma Johnstonia.*

Fig. 5. Tri-radiate spiculum of *Pachymatisma Johnstonia.*
a. Bifurcation of one of the radii.

Fig. 6. A portion of a large cylindrical spiculum of *Pachymatisma Johnstonia.*
a. Hemispherical termination.

Fig. 7. Minute tuberculated spicula attached to a fragment of a large cylindrical spiculum.

Fig. 8. Central canal of the spiculum.

Fig. 9. *Duseideia Kirkii.*

Fig. 10. Portion of a fibre of *Duseideia Kirkii*, exhibiting grains of sand imbedded in its substance.

Fig 11. *Duseideia fragilis*, (Johnston).

Fig. 12. Fibre of *Duseideia fragilis*, rendered opaque by the number of grains of sand imbedded in its substance.

Fig. 13. A smaller fibre of the same species of sponge, showing the grains of sand to be fewer in number, and disposed nearly in the centre of the fibre.

EXPLANATION OF PART OF PLATE VII.

Fig. 1. Commonest form of spiculum of *Duseideia Kirkii.*

Fig. 2. Spiculum of *Duseideia Kirkii*, with oval base.

Fig. 3. Spiculum of *Duseideia Kirkii*, with globular base.

Fig. 4. Tuberculated spiculum of *Duseideia Kirkii.*

Fig. 5. Large multi-radiate spiculum of *Duseideia Kirkii.*

Fig. 6. Curved spicula of *Duseideia Kirkii.*

XII.—*On Fossil Xanthidia.* By Henry Hopley White, Esq.

Read February 16, 1842.

I have, for some time past, directed my observations to that interesting portion of fossil Infusoria called *Xanthidia*, and which, in the recent state, forms a genus of the tenth family of the class of Polygastrica, called *Bacillaria*. In this genus the animalcule is unattached, and free from any pedicle or stalk; having a globular form, generally spherical, but in some of the species occasionally of an irregular oval. All the species of this genus have the lorica or external covering semi-transparent, and invested with tentacula, varying in form, number and dimensions: from these tentacula, each of the different species may, with little difficulty, be discovered. The arrangement which I am about to submit to the Society, of the different species of this interesting group of fossil Infusoria, is the result of much careful examination of some thousands of specimens, in flint collected from various chalk districts of England, and in some gravel flints.

The name *Xanthidium** is derived from the Greek word ΞΑΝΘΟΣ, *yellow*, the prevailing hue of these minutissimal forms of animal existence.

All the other *Xanthidia* I have met with (comprising many thousands of individuals) can be distinctly, and, as I think, satisfactorily, arranged under eleven species. There are individuals occasionally

* When the above paper was read before the Society, I comprehended under the genus *Xanthidium* a species which I called *globosum*, and placed it as the first species. I so named it because it had merely a globular form, without any tentacula or spines that I could discover. I think it is quite distinct from the fossil genus *Volvox*, which is rarely to be met with, and which is, I believe, furnished with an aperture, and transparent, having the appearance of a spherical sac or skin, none of which characteristics belong to the animalcule I called *Xanthidium globosum*, that being nearly opaque, but slightly semi-transparent towards the verge of its circumference, and without any apparent aperture. It is generally found among the various species of *Xanthidia*, and like them orbicular in form, and of a yellowish colour; and is the only other fossil animalcule which I can discover, besides the eleven species enumerated and described in the above paper, which has a well-defined spherical lorica or covering: it varies in dimensions from the $\frac{1}{100}$ to the $\frac{1}{31}$ of an inch. Upon further consideration, and in conformity with the suggestions of the Council, I have rejected this animalcule as forming a species of the genus *Xanthidium*, because it is without any tentacula or spines, and, therefore, not coming within the genus *Xanthidium* as defined by Ehrenberg. It is figured as 12 in the plate, and may be called *Globosum*, forming a genus of animalcules distinct from *Xanthidium*.

found to deviate, in some measure, from those which I now submit to the Society; but their deviation of form is to be attributed to accidental circumstances, to imperfect or distorted structure. Each of these deviations from the type of the species under one or other of which I have been able to class them, being, so far as regards the deviation of form, *sui generis*, differing from all others of the distorted individuals; so that I have never been able to discover among them all such a general character of form or resemblance as would warrant the classification of them to a separate species.

The classification hitherto recorded I consider very imperfect.—Professor Ehrenberg does not, I believe, include more than five or six species, and assigns to a distinct species some which I deem distorted varieties. The want of a nomenclature to characterize those which in my continued observations were so constantly recurring, induced me, for my own convenience (and without the most remote intention of offering the result to this Society) to adopt the arrangement of the species under the number and nomenclature I now proceed to suggest.

The eleven species I have arranged in order, as they gradually become more complex in the structure of their tentacula. I am of opinion that all these *Xanthidia* cannot properly be considered as varieties of one species, varying only in form, according to the different stages of development in their progress towards maturity or decay. The species are clearly distinct, as well in their general character, as in the details of their external structure; so that mere progress towards maturity or decay will not account for their distinctive peculiarities. Although, it is true, among the individuals of each species, I have observed more or less completeness in their specific developments; and, as before intimated, these I have deemed merely varieties from the perfect type of their respective species. With these preliminary observations I shall now enumerate and describe the eleven species of fossil *Xanthidia*, giving my reasons, as I proceed, for the nomenclature adopted.

First, *Xanthidium vestitum:* which I so name from the thin transparent membrane which extends beyond the body to the extremity of the tentacula, and by which the animalcule appears to be surrounded. It is rarely seen to encompass the animalcule as perfectly as that delineated in the accompanying drawing, the membrane being more or less broken around the outer circumference. This description is of the appearance as a superficies or disk, rather than of a solid spherical body, which it really is; and I cannot help thinking that this appearance results from a gelatinous substance in which the animalcule was

enveloped; and that the deviations from a perfectly spherical form indicate different stages of the condition of the animalcule. I am strengthened in this conjecture by several specimens in my collection, in which part of the animalcule is quite free from the surrounding mass, and the tentacula, which are almost always those of the species *ramosum* (presently to be noticed), denuded of the substance with which the other parts continue to be incumbered. Sometimes the membrane seems to adhere to two or three tentacula separately, and at other times to one only. This latter appearance suggests an enquiry, whether the species we call *crassipes*, or thick-legged, is not one of the *vestita* in progress towards a partial or entire separation from its gelatinous accompaniment; but I shall presently give my reason for thinking it is not. Whether this substance surrounds any of the other species I cannot say; possibly it may, but those which I have seen exclusively exhibit the tentacula which characterize *Xanth. ramosum*. Its diameter measures from $\frac{1}{400}$ to $\frac{1}{180}$ of an inch.

The second species I call *Xanthidium fimbriatum*, or fringed, from the short processes or stunted tentacula which densely surround the body. I have not attempted to count the number; indeed, I believe it scarcely practicable, in many instances, to count those round the outer circumference, and therefore impossible in this, and in the other species, to arrive at more than an approximation to the number of tentacula which cover the whole surface of the bodies of these globular animalcules; so that I have not attempted to make the *number* of the tentacula a specific characteristic. It might be suggested that these fringed processes are no more than the earlier indications of those tentacula, which, in the more matured growth of the animalcule, assume a much more lengthened appearance; and may be the same, in an early stage, as the *hirsutum* or *furcatum* afterwards mentioned. But whether this be the fact I cannot say, as I have not found any in such an intermediate state towards maturity as would support the conjecture. *Xanthidium fimbriatum* measures in diameter from $\frac{1}{500}$ to $\frac{1}{300}$ of an inch.

The third I call *Xanthidium hirsutum*, the name which has been given to it by former observers, and, among others, by that accurate observer, the Rev. J. B. Reade. It is so called from the hairy or furred appearance which the numerous thin tentacula assume, being in tufts, less uniform and regular in their arrangement than the next I shall notice. It is not so perfectly spherical as most of the other species; indeed the uneven tufted or matted appearance of the tentacula, like hair or fur, completely obscures the contour of the body on which

they are placed. It varies much in its dimensions, differing from $\frac{1}{500}$ to $\frac{1}{285}$ of an inch in diameter.

The fourth in order is *Xanthidium furcatum*, or forked *Xanthidium;* a name previously applied to one species by those who have preceded me. It differs from *X. hirsutum* or the hairy *Xanthidium* in the circumstance that the tentacula are far less numerous, more separated, more regularly arranged, and divergent from the common centre of the animalcule. The tentacula are slender, and gradually tapering to the extremity; and those apparent around the circumference are from thirty to forty in number, or even more: what may be the average number on the whole surface of the body, can be only roughly computed; perhaps from two to three hundred. The average diameter is from $\frac{1}{500}$ to $\frac{1}{300}$ of an inch.

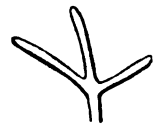
The fifth is *Xanthidium spinosum*, which I so name from the singularly long tapering tentacula which characterize this species. The individuals vary in dimensions, but, upon the whole, measuring in diameter from the extremities of the tentacula, they are the largest of the species of *Xanthidia*, except the species *tubiferum* afterwards noticed. The tentacula apparent round the circumference are from fifteen to twenty-five, and they measure in diameter from the $\frac{1}{300}$ to $\frac{1}{250}$ of an inch.

The sixth I have named *Xanthidium malleoferum*, or hammer-bearing, from the Latin words *malleus*, a hammer, and *fero*, to bear. I characterize this (as all the other species) by the form of the tentacula, as the only feature by which I can, with any certainty, distinguish one species from another. The tentacula of this species are for the most part terminated by a small process or arm, placed nearly at right angles, at the extremity of each tentaculum, which nearly bisects the little arm, and which thus forms the head of the hammer, in two equal parts; thus, or thus, which latter is a variety of this species, the two cross arms not forming a straight line at right angles with the tentaculum, but diverging from its extremity at a very obtuse angle.

The apparent tentacula vary in number from fifteen to fifty, and in length, some being very short, and thickly set round the circumference, others longer and more scanty, and approximating to one variety of *X. ramosum* next noticed, having but two instead of three points or processes at the end of the tentacula. The general form of the body

also varies, sometimes being spherical, at others irregularly elliptical. This species I find frequently broken on one side. The average size, measuring, as in the other species, the diameter from the extremes of the opposite tentacula, is from $\frac{1}{400}$ to $\frac{1}{200}$ of an inch. The most perfect I have seen is in the possession of Dr. Mantell, by whose son, Mr. Reginald Mantell, it was found in chalk flint. I had previously named this species, having long before discovered many, though less perfect.

The seventh is *Xanthidium ramosum*, or branched Xanthidium: it is the most common of all the eleven species. There are several varieties; the tentacula round the apparent circumference varying in number from fifteen to thirty: the average number is about twenty. The characteristic of this species is the branching termination of the tentacula; the terminations to each tentaculum are generally three in number, diverging from the end (as in the figure), not unlike a bird's foot, only longer in proportion and more tapering; but sometimes they are of a more complex structure, each of the three arms or terminations branching out again at their extremities (thus) into further processes, resembling the more complicated form of another species, which I shall presently notice as the tenth.



Their average diameter (measured as before) is from the $\frac{1}{400}$ to $\frac{1}{300}$ of an inch. The individuals of this species are frequently found in contact, in pairs, and sometimes as many as three appear to be attached. I possess one which is very remarkable, and the only one among some hundreds which I have discovered. The body is transparent, and within it are three red globules most clearly apparent, of an irregular oval or oblate form, composed as it would seem of a cluster of minute molecules: whether these are ova or clusters of embryo *Xanthidia*, I cannot determine; their appearance would favour the opinion that they are, if this be the mode by which they are propagated; I have figured this in the accompanying plate, No. 13.

The eighth species is *Xanthidium crassipes*, or the thick-legged, the name which has been given to it by those observers who have preceded me: and here I would remark, that whenever I could, I have adhered to the nomenclature adopted in a paper furnished by the Rev. J. B. Reade to Taylor's 'Annals of Natural History,' and I believe well known to those who are interested about this remarkable group of fossil Infusoria. The dimensions of *X. crassipes* are of the average

diameters of *X. ramosum*, but the tentacula are very irregular in form and number: generally about eleven are apparent, varying in thickness and in arrangement; and not in these particulars reducible to to any established order: out of these eleven tentacula apparent round the circumference, three or four, sometimes even five, are very thick, the remaining six or seven are more or less slender, and generally tapering to a point; some are longer than others. The outer margins of the thick tentacula are very irregular in form, generally indented or waved; and this thickness would seem to be formed by a membrane spread over and connecting two or three of the smaller tentacula; which smaller tentacula, so far as my observations extend, are not branched like *X. ramosum*, but simple like *X. furcatum*. In reference to this remarkable species, I beg to advert to the suggestion before noticed, that *X. crassipes* might be deemed a variety of *X. vestitum;* and in opposition to which I would remark that the tentacula of the two are perfectly distinct, *X. vestitum* having those of *X. ramosum*, while those of *X. crassipes* are simple, like the tentacula of *X. furcatum*. The average diameter of *X. crassipes* is from $\frac{1}{210}$ to $\frac{1}{150}$ of an inch; I have, however, one very much larger.

The ninth is the first of the three last species which I call *Xanthidia tubifera*, two out of which have been previously so named by other observers. All three species resemble each other in the circumstance that the tentacula have distinctly the appearance of tubes, being more transparent, and, with the exception of *X. crassipes*, much thicker than those of the other species of *Xanthidia;* it therefore became necessary to give them an additional designation, to mark the specific distinction of these three *Tubifera* from each other.

The first of these three *Tubifera* or tube-bearing *Xanthidia*, I call *Xanthidium tubiferum simplex;* or, leaving out the generic name, *Tubiferum simplex;* because the tubiform tentacula have a simple termination, that being of a plain circular orifice, slightly curving outwards, like the end of a trumpet or hautboy, perhaps not unlike the mouth of a leech when fixed, and in the act of drawing blood. This I have found by far the most rare species, having discovered only two or three during my researches, among thousands of the remaining species. They have, as nearly as I can count, about fifteen tentacula apparent, and they measure about $\frac{1}{150}$ of an inch in diameter.

These *Tubifera*, from their peculiar structure and substantial appearance, more than any of the other species, clearly prove that the animalcule is spherical, and armed, in all parts of the body, with tentacula.

The tenth species of the genus *Xanthidium*, and the second of the *Tubifera*, is *Tubiferum complex;* which differs from the last in this, that the tubiform tentacula have branching terminations or processes, but which are not uniform in their structure. Sometimes the orifice is separated into unequal divisions of four, five, or six parts, thus (see figure); in others like one variety of *X. ramosum* before noticed, the branching terminations being of a more complex structure, thus; each branch having at its extremes a further ramification, and which last, I am strongly inclined to consider not a variety of the species, but the same as the former in a more advanced state of development. I have arrived at this conclusion after repeated observation and comparison of many individuals of *X. Tubiferum complex* in my collection: and I think I can clearly trace among them the gradual progress of the tentacula, from the first separation of their orifices until they assume that form which I deem the perfect type of the species. The following delineations, sketched from the tentacula of two or three individuals in my collection, illustrate my observation; from these instances I further

conclude that the terminations of the tentacula, in the same individual, do not uniformly progress towards perfect form, but that some of the tentacula attain to perfect development before others. The first of these forms I consider the perfect characteristic of the species. The tentacula apparent are from fifteen to eighteen; the average diameter is from $\frac{1}{300}$ to $\frac{1}{100}$ of an inch. This is the most common of all the *Tubifera*, but all the *Tubifera* are rare compared with the other eight species.

The eleventh and last species of the genus *Xanthidium*, and the third of the *Tubifera*, I have named *Tubiferum recurvatum* or *palmaforme*, the curved or palm-formed Tubiferum; it differs from the two preceding in having the tentacula decorated at their terminations with a cluster of smaller curved processes, diverging from the orifice of each tentaculum, and inclining back in the form of a cluster of palm-leaves, from four to six in number. Next to *Tubiferum simplex* this is the most rare of all the species: the average of their diameter,

measuring as before from the ends of the opposite tentacula, is from $\frac{1}{350}$ to $\frac{1}{280}$ of an inch.

I may here observe that the recent *Xanthidia*, discovered alive in water which was sent by Professor Bailey to Mr. E. Quekett, from a pool or lake at West Point, near New York, in America, and a few drops of which were given to me by Dr. Mantell and the Rev. Charles Pritchard, of Clapham, resembled closely the fossil species of the *Tubifera* in the tubiform character of the tentacula; but in reference to the terminations of those tentacula (being trifid) they most resembled one variety of the species *ramosum*. The apparent tentacula of the recent *Xanthidia* were from nine to fourteen in number, measuring in extreme diameter $\frac{1}{250}$ of an inch. I had the gratification of seeing one of these recent specimens move its tentacula, and I preserved it in its collapsed state. I have another recent *Xanthidium* from the same source, which, to an inexperienced observer, could scarcely be distinguished from one in the fossil state.

The discovery of these recent specimens proves, beyond all doubt, that these various fossil species are animal and not vegetable substances; and judging merely from the appearance of these fossil species, we might conclude that they were living at the moment when, by some wonderful agency, they and the surrounding fluid in which they were living became converted into one solid mass of silex, assuming their present form of nodules of flint. I have, perhaps, unphilosophically said at the moment when, by some wonderful agency, these floating animalcules and the circumambient fluid which sustained them, became converted into one solid mass of silex; for I believe the formation of these chalk flints is considered among the learned in Geology a problem by no means of easy solution. That flint may be held in solution, in considerable quantity, in some fluids, I believe is certain; but by what process, by what agency, during the Cretaceous period, the flint nodules, extending in long parallel layers or veins in chalk cliffs or otherwise, assumed their present form, I must leave to those who, from their scientific acquirements, are more competent to form an opinion on the subject. Whether, by a sudden transformation, the surrounding fluid which contained these minute and delicately organized modifications of animal existence we have been describing, was, with its numerous inhabitants, converted into its present condition of flint; or whether, by the gradual deposit of minute particles of silex, held in solution by the fluid which contained these minute animalcules, the continuous aggregation became nodules of flint, as we now find them, in various chalk districts in England; or whether, by some

other wondrous and inscrutable agency, a process altogether different from either of those supposed, these mausoleums of countless myriads of once living beings (now fossil Infusoria) were produced;—I feel myself incompetent to surmise, having but little acquaintance with those sciences which bear upon this subject of acknowledged difficulty. But certain it is that mere appearances would seem to justify the first hypothesis of sudden transformation, however it may militate against the more favoured opinions of geologists, versed also in the science of chemical agency. It cannot fail to arrest attention, that delicate as is the structure of these minutissimal creatures, there is not, in by far the greatest proportion of them, any appearance of distortion, pressure, or injury of any kind; they seem to have been suddenly arrested in the full enjoyment of life, developing (so far as form and perfect structure can evidence the fact) every indication of animation exhibited by the recent species, up to the very moment of their transformation from the living to the fossil animalcule. I offer these observations with diffidence, not as opinions formed, but as queries from one who, though deeply interested in the pursuit and advancement of science generally, has no pretension to any attainments in those sciences in particular, which more immediately relate to the subject of these last observations. They are made with a view to elicit information, and to lead to further research. Upon the present subject Dr. Mantell's remarks better harmonize with the more generally received opinions on the formation of flint in chalk. "This arrangement," he observes "has probably arisen from the chalk and flint having been held in suspension or solution in the same fluid, and precipitated into the bottom of the ocean, when consolidation took place, the siliceous molecules separated from the cretaceous, on the well-known principle of chemical affinity, the sponges and other Zoophytes acting as nuclei or centres, around which the siliceous matter coagulated." *

But whatever be the mode or the agency by which the changes were effected in those conditions of the earth's surface, which characterize the Cretaceous period, we have, in these flints, records of animal existence, as convincing and irrefragable as in those more gigantic memorials of the earth's inhabitants in former epochs of its dark history, whether in the form of the Icthyosauri, the Iguanodon, or the fossil remains of beings of still more remote antiquity. We have, in every section of a flint nodule, proofs that in the former

* 'Wonders of Geology,' vol. i. 294, Ed. 1840.

periods of the surface of our planet, the lines of the poet were then, in part at least, as applicable as now, when he says —

> "See through this air, this ocean and this earth,
> All matter quick and bursting into birth."

Neither will the cloud of impenetrable mystery which hangs over the earlier changes of the earth's surface, prevent the accurate observer of the countless reliquiæ of its former wonders from admiring the same indications of infinite wisdom and power, which still captivate the devout philosopher in his investigation of those teeming myriads of living animalcules, now existing in almost every modification of matter, which clothes its present surface with beauty, fertility and abundance.

Clapham, Surrey,
February 16, 1842.

EXPLANATION OF PLATE VIII.

Fig. 1.	*Xanthidium vestitum.*
Fig. 2.	„ *fimbriatum.*
Fig. 3.	„ *hirsutum.*
Fig. 4.	„ *furcatum.*
Fig. 5.	„ *spinosum.*
Fig. 6.	„ *malleoferum.*
Fig. 7.	„ *ramosum.*
Fig. 8.	„ *crassipes.*
Fig. 9.	„ *Tubiferum simplex.*
Fig. 10.	„ „ *complex.*
Fig. 11.	„ „ *recurvatum* or *palmaforme.*
Fig. 12.	„ *globosum.*
Fig. 13.	„ *ramosum*, variety.
Fig. 14.	Recent *Xanthidium* from New York.

XIII. — *On a New Species of Fossil Xanthidium.* By H. H. White, Esq.

Read December 21, 1842.

In the paper which I had the pleasure of presenting to the Society in February, 1842, upon the fossil *Xanthidia*, I described and figured, as the result of my observations, eleven species, exclusively of a fossil-animalcule abounding in flints, which I called *globosum*. Since that time I have discovered another species, clearly distinguishable from the eleven, and of which I beg to offer to the Society the following description, accompanied with a drawing:* I class it as one of those species called *Tubifera;* but it differs from the three species of *Tubifera* described in my former paper, in the following particulars: — that the tentacula are longer, and instead of possessing any process at their extremities, they gradually taper to the finest point; the tentacula apparent are from eleven to twelve, quite straight, and free from any appendage whatever. This species measures about the $\frac{1}{100}$ of an inch in diameter, including the extreme points of the opposite tentacula. It is distinguishable from the *Xanthidium spinosum*, which it in some measure resembles; the tentacula of the latter are also tapering to a fine point, but they are waving, irregular, much more numerous, and without the tubiform appearance of the new species. I think it is not advisable to alter the nomenclature already before the public; and although the species now under consideration might be deemed the most simple in form of all the *Tubifera*, I would not suggest a transfer of the name *Tubiferum simplex* from No. 10, in the species described in my former paper, to the new species, but prefer giving the latter the new name of *Tubiferum spiculatum*, forming the twelfth species of the fossil *Xanthidia*.

* Plate xx. fig. 4.

XIV. — *Observations on the Young of a Species of Ixodes from Brazil.* By George Busk, Esq.

Read April 27, 1842.

At the last meeting of the Society, I presented some small living *Acari* which I had received from Rio Janeiro. They came inclosed in a letter, and had been sixty or seventy days on their passage, but were then, and still are living. They were sent to me as specimens of an insect called by the Brazilians, the *Carapato*, and which was stated to be the cause of great mortality among the cattle in those countries, and very troublesome to travellers, by the great irritation and annoyance they produce. Since then I have been enabled, by the kindness of a gentleman who was long resident in Brazil, and who had suffered much by loss of cattle caused by this troublesome insect, to collect additional information about it. I submitted queries, to which he has furnished the following replies.

1. The name of *carapato* or *carapat* is given to the insect, in consequence of its resemblance to the seed of the *Ricinus*, which has that name in Portuguese.

2. It is common in all parts of South America where cattle abound.

3. It infests cattle, horses, dogs and sheep.

4. It is not found on plants; and cattle generally become infested with it when feeding in open and exposed pastures, where the sun's heat is great; and it increases most in dry seasons.

It is generally supposed that the insect was not seen in the Brazils previously to an excessively hot and dry summer, about 1824 or 25, since which it has multiplied amazingly. It is remarkable that cattle feeding in shady pastures and coppices, are frequently quite free from the carapato, but will acquire it by infection from others.

5. The mode in which it appears to cause destruction to the animal infested by it, is by the incessant irritation which prevents the animal feeding or resting, and in consequence it becomes worn out.

6. They first appear on those parts of the skin uncovered by hair, and are then not larger than a pin's head, and make the part quite black by their numbers. They adhere so closely, that scraping them off would tear up the skin. In a short time they increase to the size of a bean, or common tick, as seen in dogs, and fix themselves promiscuously on all parts of the hide, where covered with hair.

7. The same species appears to insinuate itself, in its incipient state, upon the human body, but is not known to assume the tick form there. They adhere most tenaciously to the skin, and are believed to introduce themselves below it. They are very harassing, and even create soreness and inflammation. They generally affect persons who have been passing through woods, but are not known to be ever seen or found on trees or plants.

8. Many thousand head of cattle are annually carried off by the carapatoes, and frequently a scarcity is thus caused.

This is all the information I have been able to collect on the subject, and I am not aware that any other account is given by travellers in South America.

From the above particulars it would appear that the little acaroid insect now before the Society is only the young of a much larger species of tick. What this species may be is perhaps not to be determined in the absence of full-grown specimens; but from the structure of its oral apparatus, it is plainly to be referred to the genus *Ixodes* of Latreille; with respect to which it is stated by Cuvier, that "they are found in thick woods, abounding in brush-wood, briars, &c., attaching themselves to low plants by the two fore legs, extending the other feet. They fasten upon dogs, cows, horses and other quadrupeds, and even upon the tortoise, burying their suckers so completely in their flesh, that they can hardly be detached by force, and by tearing away the portion of skin to which they are fastened. They deposit a prodigious number of eggs. Their multiplication upon the ox and horse is sometimes so great, that these animals perish from exhaustion. The tarsi are terminated by two ungues, inserted upon a plate, or are united at the base upon a common peduncle," &c.

In these particulars, it will be observed how closely the above description coincides with the statement I have above given on the subject of these observations. But no mention is made of any difference between the immature and the full-grown insect; and consequently, perhaps the present account may not be unimportant to those who are engaged in the study of the still confused but highly interesting parasitic Acaroidei.

Figs. 1 and 2 (Plate ix.) represent the dorsal and abdominal aspects of the insect, which, in its present state, has only six legs, in which it agrees with the group Microptheria of Latreille, which thus differ from other Acaroidei. In this respect, however, it is not peculiar, some species of *Hydrachna*, in the young state, also possessing but six legs.

The body is rounded. The posterior or abdominal portion, consisting of a membranous sac marked with delicate lines, and allowing the cœcal sacs of the intestine to be seen through it: fig. 1. The anal orifice is about the middle of the abdomen inferiorly: fig. 2. The anterior part of the body, on the back, is covered with a horny shield, which partially covers the oral apparatus or head, and presents a contraction opposite the junction of this apparatus with the trunk: fig. 1. The oral apparatus or head consists of two lateral palpi with the maxillæ to which they are attached, of a sternal labium and two mandibles.

The palpi (*c*, fig. 1, 2, *a*, fig. 5, 6) are thick and hollow, and beset with long hairs or spines, and have inferiorly at their extremities a papillary process set round with long spines, which is apparently retractile, as seen in fig. 8, or extended in fig. 7. These organs are not perforated. The maxillæ are seen at *c*, fig. 6. The mandibles (*b*,*b*, fig. 7) consist of a delicate, transparent, scaly sheath, surrounding a tubular apparatus which contains the organs by which the tick obtains its nutriment. These organs are more fully represented in fig. 9, and consist of two blades, one for cutting and one resembling a saw, besides a hook, and a small tube with a projecting lip a little below its extremity, and evidently for the purpose of suction. This smaller tube (*a*, fig. 9) is articulated just within the orifice of the larger one, and is apparently furnished with muscles, by which it can be moved in any direction, or retracted. In the usual state of the animal, this collection of instruments lies concealed within the larger tube, which is again enclosed within the transparent sheath, and the two mandibles are closely embraced by the palpi, and supported below on the sternal labium; but by moderate pressure between glass, the apparatus can be made to expand, as in fig. 7, 8, where the extremity of the large central tube of the mandible is extruded from its sheath, and opens on its external side, to allow of the projection of the enclosed instruments. The inner portion of the tube forms a sort of hood or lid, and is articulated so as to perform that function.

The sternal labium is represented at *a* (fig. 8), and is remarkable by its curious scales.

The intestinal canal appears to be continuous with the tubes of the mandibles, which are evidently prolonged into the trunk, and it presents numerous large cœca. From the immature condition of the present specimens, no reproductive organs are to be distinguished: nor can I perceive any circulation, nor any tracheæ.

The legs consist of seven joints, and are of nearly equal size and

length. They are attached to the anterior half of the trunk, inferiorly. The tarsi are terminated by fan-like expansible feet, furnished on the back with long recurved claws. The feet, which are beautiful microscopic objects, are represented in the expanded state at fig. 4; and one of the legs, with the foot contracted, in fig. 3.

From the foregoing I conclude: —

1. That the *Acari* now presented to the Society are the young of a species of *Ixodes*.

2. That they are gifted with extraordinary powers of vitality in the absence of nutriment of any kind.

3. That this genus has no mouth, properly so called, but imbibes its food through two suctorial tubes contained in the mandibles.

DESCRIPTION OF PLATES IX. AND X.

PLATE IX.

Fig. 1. Dorsal view of the Carapato. *b*. The mandibles. *c*. The palpi.

Fig. 2. Abdominal view of ditto. *a*. The sternal labium. *c*. The palpi.

In these two figures the smaller one is magnified about 18, and the larger one about 50 linear.

Fig. 3. One of the legs with the foot contracted.

Fig. 4, 4′, 4″. Magnified views of the feet when expanded, in three different positions.

PLATE X.

Fig. 5. The head magnified, seen from above. *a*. The palpi. *b*. The mandibles.

Fig. 6. Magnified view of the head &c. seen from beneath. *a*. The palpi. *b*. The mandibles. *c*. The maxillæ. *d*. The sternal labium.

Fig. 7. The oral apparatus, highly magnified, seen from above. *a*. The sternal labium. *bb*. The mandibles. *cc*. The palpi.

Fig. 8. Magnified view of the oral apparatus, seen from beneath. *a*. The sternal labium, showing its curious scales. *bb*. The mandibles. *cc*. The palpi.

These two figures are magnified about 150 linear.

Fig. 9. One of the mandibles with the organs of nutrition, magnified about 300 linear. *a*. The suctorial tube. *b*. Blade resembling a saw. *c*. Blade for cutting. *d*. Hook.

XV. — *On the Minute Structure of certain substances expelled from the human intestine, having the ordinary appearance of shreds of Lymph, but consisting entirely of filaments of a Confervoid type, probably belonging to the genus Oscillatoria.* By ARTHUR FARRE, M.D., F.R.S.

Read June 22, 1842.

ON a former occasion I laid before the Society the results of my observations upon a remarkable and exceedingly rare parasite of the human body, the larva of the *Anthomyia canicularis*, which was expelled in vast numbers from the intestine. The subject of the present communication must also, I presume, be classed under the head of parasites, but occurring under such a remarkable form, as to render the determination of its precise nature a matter of not very easy accomplishment.

The individual from whom the substances which I shall describe were obtained, is a married female, aged thirty-five, residing at No. 28, Crown Street, Soho, who is now attending as an out-patient under my care, at King's College Hospital. She is a moderately stout and healthy looking person, but has been slightly ailing for the last twelve months, and for six weeks past has been subject to menorrhagia, by which she has been somewhat debilitated: she has also suffered lately from slight dispepsia. Six days ago, after suffering considerable griping pains in the bowels, which continued for twelve hours, she passed *per anum* a number of shreds, which being discharged with some difficulty, and causing an obstruction of the bowel, her attention was thereby more particularly attracted, and some of the shreds were pulled away by herself, so that there can be no question as to the source whence they were derived.

The substances thus passed were placed in water, and brought by the patient for my inspection. They had so much the appearance and ordinary characters of shreds of lymph, or false membrane, that I had not at that time the slightest suspicion of their being anything else, and merely reserved them for a more particular examination at some future period, but without any expectation that they would present appearances different from the ordinary microscopic characters of false membrane. I was therefore much surprised, on placing a small portion of the substance under the microscope, to find that it presented the appearance of a mass of *Conferva*, and that, in fact, the

entire substance was made up of nothing else but tangled filaments of a confervoid type. However, before describing the microscopic characters of this singular substance, it will be necessary to give some idea of the appearance of the mass, as examined without the aid of the microscope. I have already compared the substances to shreds of lymph or false membrane; such shreds or flakes of soft yellow matter, assuming a membranous form, are familiar to every one accustomed to pathological researches. It is well known that they are often the result of inflammation attacking membranous surfaces, and that they are most frequently met with on the serous membranes, as the pleura, pericardium and peritoneum, but that they are also occasionally, though more rarely, produced from mucous surfaces, as those which line the air-passages and alimentary canal. Of the same nature as these have been also generally considered those fibrinous flakes which are occasionally passed from the intestines in chronic affections of the mucous membrane of those parts, and which sometimes assume the form of tubular casts, evidently moulded upon the surface of the gut; and lastly, I may allude to a more common affection of another mucous surface, the lining membrane of the uterus, on which membranous substances are occasionally formed and discharged, constituting a complete cast of the organ, and familiar to every practitioner as occurring occasionally in cases of dysmenorrhæa.

I allude to these examples (familiar enough to medical men) for the purpose of showing to those who have not directed their attention to such subjects, that membranous or fibrinous substances are occasionally discharged from the various mucous surfaces of the body, which are generally considered to be the product of inflammation, either acute or chronic, and are closely allied in composition and ordinary characters to the fibrinous part of the blood, from which fluid they are apparently separated by the inflammatory process. With such knowledge therefore we should, I think, be but little prepared to find that flakes or shreds of a membranous substance, having so much of the ordinary appearance of the substances which I have just described, that several medical friends to whom I have shown them, have at once supposed them to be the ordinary flakes of false membrane discharged from the bowels, should, when microscopically examined, present all the characters of those confervoid masses which are to be found in almost every water, but the appearance of which to the naked eye is so totally dissimilar to that of the substances under consideration, that no one could for a moment suppose, without the aid of

the microscope, that they were, in the slightest degree, allied to each other.

The several portions of this substance in my possession, differ from each other in some respects in reference to their external characters, though in their composition all are alike. Some of the portions are in the form of riband-shaped masses, of which the largest is six inches in length, varying from half to three quarters of an inch in breadth, and is about a line in thickness, (Plate xi. fig. 1): there are five or six portions of similar breadth and thickness, and varying from one to two inches in length. These portions are highly elastic, and may be stretched to a considerable length, returning again to their former shape with considerable resiliency. This elasticity however is chiefly observed when the pieces are stretched in the longitudinal direction, as they are capable of very little extension transversely. The margin of some of these portions is irregular and flocculent, being formed evidently of minute filaments, and resembling the villous surface of a mucous membrane, and in the largest piece the whole surface has this velvety appearance. Others of these portions present more distinct evidences of a fibrous arrangement, (fig. 4), and distinct traces of fibres, or, as they will be presently shown to be, bundles of filaments, may be observed extending through the mass, both longitudinally and transversely, but the surface or the margins still preserving a flocculent appearance. One or two of these pieces, of which the border is nearly smooth, present very much an appearance of having been cast in a flattened or contracted portion of the small intestines; one of these especially (fig. 3), which is only four lines in width, looks like a portion of the intestine of some small animal, with its mucous membrane turned externally and flattened, but, like the other portions, it is not hollow, but riband-shaped. The remaining portions differ from these only in presenting no trace of the flocculent surface or margins, and in being more completely membranous. They might, in fact, be easily mistaken for portions of animal membrane, and being of a closer texture have much less elasticity than the former portions. The thinnest of these portions, which at its edge is nearly diaphanous, is very smooth and shining, having almost a tendinous lustre. To the naked eye it appears to be made up of fibres, both longitudinal and transverse, but the longitudinal prevail, and the mass more readily splits in that direction, the splitting taking place with a clean margin, as if cut with a sharp instrument. This fragment bears no distant resemblance to a piece of *dura mater*, covered by the arachnoid membrane (fig. 2); both surfaces are equally smooth, and no appear-

ance is presented of any surface for attachment. The remaining portions are thicker, measuring nearly a line in thickness, and present a more distinct appearance of fibres crossing at right angles. They may, in fact, be readily split into masses of fibres, which very closely resemble, both in colour and texture, the middle or fibrous coat of the arteries, but being softer and more elastic. The whole of these portions are of a buff colour, and are here described as they appear when examined under water.

When a small fragment of any of these masses is placed under the microscope, with an amplifying power of from 50 to 100 linear, it is seen to be made up of very delicate filaments, the $\frac{1}{7000}$ of an inch in diameter, which are differently arranged in different specimens. In those portions which have a flocculent surface and loose texture, the filaments are seen to be coiled up and interwoven in a tangled mass, which presents no appearance of any definite arrangement (fig. 6): at the edges of such portions the filaments are seen distinct and separate from each other, and shooting free into the surrounding fluid; but the examination of the centre presents a confused appearance where the fibres cross each other in all directions, and intermingled with them are seen some irregular granules of the same colour as the mass. When those portions however are examined which have a *membranous* character, a very distinct and definite arrangement of the fibres is perceived, which here cross each other nearly at right angles, and are so interwoven as to form a layer of greater or less strength and thickness, (fig. 5); and it is apparently entirely owing to this variety in the mode of arrangement of the fibres, that the different appearances in the several masses already described are produced: the tangled and confused aggregation of fibres producing the villous masses, the loose ends of the filaments constituting in fact the villosity, and the regular crossing of the fibres giving rise to the smooth, shining membranous expansion.

To examine however the minute structure of these filaments, which make up, in fact, the whole mass of these singular substances, with the exception of the granules just noticed, and which are few in number, it is necessary to use a magnifying power of 500 or 600 linear, and the appearances then observed will be best described by the aid of a diagram, (see Plate xi. and the description).

The filaments which have been just described, are so exceedingly minute, and require such high powers for their examination, that it must be a matter of some difficulty to determine their exact nature. The *confervoid* type however is, I think, so very strikingly and obvi-

ously exhibited, as to leave little room to doubt the class of products to which this substance is to be referred. That it is no animal membrane or product of inflammation, as it would at first sight appear to be, before it had been submitted to the test of the microscope, will, I think, be readily admitted by all who have ever had the opportunity of examining these substances. The texture to which perhaps it approaches most nearly, is the *muscular*, and that in the invertebrate classes only, in many of which the filaments composing that texture are disconnected, and not bound up in bundles and enveloped in sheaths, as in the Vertebrata, to which, therefore, the arrangement here described can bear no resemblance; but the resemblance to muscular texture at once vanishes when we apply the higher power, and discover the intimate structure already described.

If, as I presume will be the case, the product be admitted to belong to that group of Cryptogamic products which have been generally classed together under the title of *Confervæ*, it then remains to determine whether this specimen belongs to any known genus or species, or is as yet undescribed. I am inclined to refer it to the genus *Oscillatoria*, but am not acquainted with any *species* with which it is identical. Its resemblance to *Oscillatoria* is seen in the extreme delicacy of its filaments, in its simple transverse markings, and the separation of the green matter at intervals within the sheath by which those markings are produced. In colour it resembles *Oscillatoria ochracea*, but that species is extremely brittle, and can scarcely be handled without breaking up into fragments, while this is very tough and elastic. I am inclined to consider it a new species, if not a new genus.

Further opportunities of examining this product, supposing it to be allied to or to belong to *Oscillatoria*, may probably throw some light on the disputed question of the animal or vegetable nature of that genus, which appears to be now one of the many bones of contention between the botanist and the zoologist. Perhaps the chemical analysis of this substance, which I have not yet had an opportunity of instituting, may throw some light upon the question. I have already alluded to the resemblance in colour and other particulars, of this substance to animal matter; it appears also to be disposed to a similar putrefaction, for on opening the phial this morning, in which the substance was contained in a weak solution of salt and water, I perceived a very distinct odour, similar to that of decomposing animal matter, and I find that these specimens are not now so perfect as when I first examined them.

With regard to the source from which these bodies could be de-

rived: since similar organisms are abundant in every water, there can be no difficulty in supposing that a portion of the substance itself, or some of its reproductive germs or sporules, may have been swallowed by this individual in the water which she drinks. I have made particular enquiry as to her diet, and find that it is of the ordinary description, both animal and vegetable, and that her drink is limited to tea and water, but of the latter she takes very little. The water is supplied by the ordinary service-pipes of the metropolis, and not from any particular well or pump.

At this point of the enquiry the same difficulty occurs as in the question of the origin of the ordinary internal parasites of animals, the Entozoa. Whence are they derived, and how is their existence in the body to be explained by reference to an external origin, since they are not found in any other situation? It would be almost impossible to conceive that the substance which I have described could be found out of an organized body, for example, in a stream of water; but I would suggest, that having derived its supplies of nourishment from an organized body (in this case, as may be presumed, from the surface of the intestine), its characters may have been so far modified consisting in fact, as it does, of animal matter, as to render the object no longer recognizible as an already existing species.

I believe the fact which I have just announced is new to science; I have not myself met with any similar instance, but it belongs to a class of facts which modern microscopic investigation is rapidly rendering familiar to all who value that species of observation. In the journals of the day may be found numerous examples of parasitic growth from various parts of the bodies of animals, and even of man. From the surface of the body, as in the confervoid growths attached to the fins and gills of fishes, and cryptogamic vegetation constituting the essential part of certain morbid products, as in the porrigo of the human subject. Other examples are recorded of internal vegetations, *Entophyta* as well as *Entozoa*, as from the lungs in birds, and even of the human subject, as recorded by Dr. J. H. Bennett, in a case where such organisms were expectorated by an individual under pulmonary consumption. Mr. Goodsir has related a case in which thousands of animals, allied to the genus *Gonium*, were vomited from the human stomach; and to the mass of evidence which is thus rapidly accumulating, of parasitic growths, both animal and vegetable, infesting the bodies of man and animals, I beg to add the details of the analogous formation which I have just had the honor of describing to the Society.

EXPLANATION OF PLATE XI.

Fig. 1. One of the larger portions of membrane. This was of a loose texture, flocculent on the surface and very elastic. It is represented of the actual size. These portions readily broke when lifted out of the water, and quickly decomposed, even in salt and water.

Fig. 2. A portion of the more dense membrane, having a smooth shining surface, firm texture, and distinct fibrous structure.

Fig. 3. A portion resembling a cast of the intestine.

Fig. 4. A portion showing the fibrous arrangement when torn: magnified two diameters.

Fig. 5. A small portion from the thinnest margin of fig. 2, showing the direction of the fibres crossing each other nearly at right angles, and with considerable regularity. The firmness of texture and membranous character of these portions, are owing apparently to this arrangement. Magnified 80 diameters.

Fig. 6. A portion of fig. 1, magnified 200 diameters. In this figure, the tangled arrangement of the filaments is shown, which characterises all the looser and more flocculent portions. In some parts the filaments are shown split longitudinally.

Fig. 7. A similar portion, in which the filaments are slightly stretched across the field. The longitudinal splitting and transverse markings of the filaments are distinctly seen.

Fig. 8. The same characters shown more distinctly, magnified 350 diameters.

Fig. 9. The transverse markings are here shown to be produced by transverse septa, dividing the filaments apparently into cells, filled with green matter. The *transverse* splitting of the filaments takes place at these joints. When the splitting takes place *longitudinally*, the laceration passes through the centre of the cells, which are laid open, and the margins of the laceration have a notched appearance.

XVI.—*On a peculiar arrangement of Blood-vessels in the Air-bladder of Fishes, with some remarks on the evidence which they afford of the true function of that organ.* By JOHN QUEKETT, Assistant Conservator of the Museum of the Royal College of Surgeons of England.

Read July 20, 1842.

THE singular and beautiful manner in which the minute blood-vessels of the various tissues and organs of the animal body are arranged, have formed, since the time of Malpighi, Ruysch, Lieberkuhn, and the older anatomists, some of the most interesting and important subjects of microscopical investigation. So constant is the distribution of the capillary vessels in the same tissue or organ throughout the animal kingdom, that not only can they be classified, but even the particular function which a part performs can, by the initiated, be at once pronounced from an inspection of its blood-vessels. The researches of Mr. Dalrymple, "On the Vascular Arrangement of the Capillary Vessels of the Allantoid and Vitelline Membranes of the incubated Egg," which were communicated to the Society at one of its earliest meetings, affords an excellent example of the importance of this subject, since from the arrangement of the capillaries alone in the injected allantoid membrane, he has by the assistance of the microscope been able to point out the true respiratory function of this membrane, by showing that the vascular net-work is precisely similar to that found in the lungs of other vertebrate animals, and by this means to settle satisfactorily a long-disputed question.

Among the most common, and now most easily recognized classes of vessels, are those which characterise the cutaneous, muscular and respiratory systems. Most anatomists are familiar with other classes, but to no known class that I am aware of, can some of those found in the air-bladders of fishes be at present referred. Anatomists, with very few exceptions, appear to have passed over this subject in silence. All authors agree in mentioning the fact of the great vascularity of the interior of the bladder; but the minute vascular arrangement which could not well be studied without the aid of injection, has been overlooked: the great difficulty of injecting fish, on account of the weakness of their vessels, is perhaps the principal reason of this part of their anatomy being undescribed. The difficulty of the injection must have been well known to Fischer, a German anatomist, for

in his work on the air-bladder the following passage occurs. "With all the pains that I took to inject the vessels on every side, and even with the assistance of my friends, Herr Benad and Herr Steiniger, both very dexterous in dissecting, all our endeavours were fruitless. These vessels are so minute, even in fish of a considerable size, that the patience of Carolini was even insufficient to follow them."

Before entering on this subject, it will be necessary to make some remarks on a few of the many kinds of air-bladders met with in fishes generally; and for my present purpose it will be merely requisite to divide them into three classes.

1. Into those which are simple musculo-membranous sacs, having no duct of communication either with the alimentary canal, or in fact any external opening. This kind of bladder is found in the cod tribe, in the gurnard, sword-fish, haddock, perch, and many other fish.

2. Into those that are single, but have a duct of communication which is termed (always when it is found) *ductus pneumaticus* or air-duct. This opens sometimes into the stomach or œsophagus or some part of the alimentary canal. Instances of this kind are found in the pike, salmon, sturgeon, trout, and many others.

3. Into those which are double, the two compartments being kept together, or rather communicating with each other by a narrow tube, and the *ductus pneumaticus* in all cases proceeding from the posterior compartment. We have numerous examples of this kind of air-bladder in most of our fresh-water fishes, as the carp, barbel, tench, roach, chub and gold fish.

The first class of air-bladders, or those which have no duct of communication, are generally found in those fish which frequent deep water; and in the interior of the bladder is situated a highly vascular body, termed by authors the gland for secreting the air. Of this kind of air-bladder we have an excellent example in the common cod; in this fish it is a thick muscular bag, of a pyriform figure, indented at the margins, and firmly attached to the bony framework of the vertebræ and ribs, and having two tubular processes, about three inches in length, one on each side, proceeding from the upper part of the bladder, and provided with blind extremities. They are curved upon themselves, and the curved portion lies in a cavity in the head of the fish, near to the labyrinth of the ear. From this circumstance, the air-bladder has been supposed, by Professor E. H. Weber and others, to be concerned in the function of hearing. The outside of the bladder is invested with a thin membrane, continuous with that of the peritonæum, which lines the whole abdominal cavity; and beneath

this we have two layers of muscular fibres. The interior is lined with a thin membrane of silvery whiteness, which, when examined microscopically, is found to be composed of a series of fibres, covered with a basement of membrane provided with scales of epithelium.

Beneath this membrane we have a layer of vessels, which are very remarkable for the peculiarity of their arrangement. Near the upper part and on the ventral surface of the bladder, is situated the glandular body before spoken of: it is of an oval figure, somewhat resembling in shape an exogenous leaf of that kind termed by the botanist *peltate* or *shield-shaped;* and to this so-called gland, anatomists have assigned the function of secreting the air contained in the bladder. It is largely supplied with blood, for in fact it is made up of little else than bundles of parallel vessels, and with it are connected all the large trunks which supply the whole of the interior of the bladder. The gland receives its supply of blood from the aorta high up, and the artery passes into the bladder immediately over the middle of the gland; it then divides into a great number of branches, each one of which again divides and subdivides, and ultimately terminates in a brush-shaped appendage, about three lines in length, which is entirely composed of a bundle of parallel vessels, which are very minute, (Pl. xiii. fig. 3); and each vessel, when it has arrived at the free extremity of the gland, bends upon itself and forms a loop, and returns again (fig. 3, *a*). These parallel vessels are the true capillaries of the gland, and the loops are the points at which the arterial system joins the venous. By a little trouble the whole of this body can be separated into a series of these brush-shaped appendages, each one of which gives one such an appearance as is represented in Pl. xiii. fig. 4. When the gland is entire, it presents a slightly lobulated character, the division into lobules being made apparent by the large trunks going to and from the brush-shaped appendages, which are themselves connected together by the same silvery kind of tissue as that which lines the whole of the interior of the bladder. When the vessels have been well filled, the free surface of the gland is made red by the injection; but in those parts where the injected fluid has not reached the extremity of the brush-like appendages, then it is of a light brown colour. It is loosely connected to the thin lining membrane of the bladder, and can readily be removed with that membrane, the only firm point of attachment being that part where the vessels enter the bladder. The distribution in the other part of the bladder is no less remarkable than it is in the gland. The vessels which take their supply from and return their blood to the gland, are, in the specimen

before us, three in number, running always quite parallel to each other: the middle one of the three is much smaller than the two outer ones, and is the artery, whilst the two larger trunks are the veins, (Pl. xii. fig. 3). In those fish in which I have succeeded in injecting both arteries and veins, three trunks are seen; but when only the veins have been filled, then there are but the two outer ones, the small artery between them being just perceptible, in the uninjected state. When the ramification of these trunks takes place, each of the three divides into two branches, which branches are nearly of the same diameter as the original trunks, and they cross each other obliquely, and produce an appearance not unlike the Roman letter Y; this can be explained better by a reference to Pl. xii. fig. 3, than by any verbal description. At the back part of the bladder which is attached to the spine, there is another set of vessels of an arborescent figure, and they run at right angles to the body of the fish; these appear to be connected more with the kidneys than with the air-bladder.

The parallel arrangement of vessels appears to be constant in the air-bladders of fish, there being but slight modifications of this plan in all the species of fish which have been examined: in those fish in which the bladder is double, as in the carp, tench, barbel, chub, roach &c., this arrangement is found only in the posterior compartment, in many fish they can be well examined, even without the aid of injection, for the vessels are, in most cases, filled with blood, and the contrast between them and the silvery lining membrane of the bladder makes them the more evident.

In the pike the air-bladder is a single one, but it has an aperture of communication, or *ductus pneumaticus*, but no gland, as in the cod. In this fish the distribution is very analogous to that which prevails in the cod, but instead of having only three vessels, there are as many as five or six running quite parallel to each other (Pl. xii. fig. 5); and when a branching off takes place, each of the three trunks nearest to the side from which the vessels are to arise splits into two, and again six parallel trunks are formed; these again divide and subdivide to their terminations. It is only here and there that we have a crossing of the vessels as in the cod, as the branches arc given off first from the right side, then from the left, and so on alternately.

In the perch, which is remarkable from its having an air-bladder without any *ductus pneumaticus* as the cod-fish before alluded to, we have a glandular body not in one compact mass, but scattered about the interior. The bladder itself is very thin, and when distended occupies a very considerable portion of the abdominal cavity, and the

scattered portions of the gland are very visible through the transparent parietes of the bladder. Each branch of any considerable size which is given off from the main artery supplying the bladder, ends in three or four of the brush-shaped appendages, as in Pl. xiii. fig. 4, and even in the uninjured state they appear to the unassisted eye as so many clusters of *Vorticellæ*, or bell polyps. The arrangement in the other part of the interior of the bladder is of the parallel kind before described as occurring in other fishes, but the muscular structure of the bladder appears but little developed, as its parietes are very transparent.

In the eel, the air-bladder is very remarkable; and this is the only fish in which I have been able to inject satisfactorily the upper part of the bladder. This part, described by most authors as communicating with the œsophagus (Pl. xiii. fig. 1 *a*), is exceedingly thin, and the vessels which ramify in its interior, are very visible through its parietes. It joins the second portion of the bladder at a very acute angle about its middle (Pl. xiii. fig. 1*b*). This last portion is spindle-shaped, and much thicker than the first, and is invested with several layers of a silvery membrane, which renders it opaque. At the point of junction of these two compartments we have two glandular bodies, placed one on each side of the duct of communication between the compartments, (Plate xiii. fig. 1 *d*); these are compact and hard, and, like the same parts in the cod fish, are composed entirely of parallel vessels, and with them are connected all the trunks which supply the posterior compartment of the bladder. The blood is received from the aorta very high up, and is first distributed to the upper compartment, then it goes to the two glandular bodies before spoken of, and from them is distributed to the whole interior of the posterior portion of the bladder, and returned again by a large vein, which may be very well seen in the thin membrane, running in a direction nearly parallel to the artery. The arrangement of vessels in the upper compartment is very peculiar, and approaches nearer to that of the cellular lungs of the Reptilia than any other system, in which animals we have a single twig, dividing into net-work of nearly equal-sized capillaries, the interspaces or meshes being also remarkable for the equality of their size. In the posterior compartment, the distribution is somewhat similar to that in the upper part, but the branches are far more tortuous, and few if any meshes are formed, (Pl. xii. fig. 4); and both arteries and veins have the same arrangement, and run parallel to each other, and when one system of vessels is successfully injected,

the other gets filled as well, so that the course and communication of the arterial and venous vessels can readily be made out.

In the gurnard the air-bladder is short and very muscular; it has no *ductus pneumaticus*, but, like that of the cod, is provided with a gland, and with the same parallel distribution of vessels: the same structure also is found in all the fish which I have had an opportunity of examining, these now amount to upwards of thirty species.

Having said thus much on the peculiar arrangement of the capillary vessels in the organ in question, it now remains for us to consider whether any light can be thrown upon the function which the air-bladder performs, from an inspection of its blood-vessels. To enumerate all the authors who have written on this subject, would be a task of no small moment, and for our present purpose such a recital would be useless. Suffice it to say that the talents of a Cuvier and a Hunter have been employed in the investigation, and the true use of the air-bladder, to the present day, remains as an unsolved problem, and the points at issue are these, whether it acts only the part of a float, or whether it is at all concerned in the function of respiration. If all fishes were supplied with an air-bladder, the question could be settled without much difficulty, but such is not the case. Mr. Yarrell, in his 'History of British Fishes,' informs us, that "one fourth of the fishes known have no air-bladder at all, and that two thirds of the other three fourths have neither canal nor aperture for external communication." Besides this, the air-bladder is said to be present in one species of a genus and absent in another. Our common mackerel (*Scomber Scomber*), is said to have no air-bladder, whilst of the same genus, *Scomber pneumatophorus* has one. Many other instances of this kind could be mentioned. The flat fish, and most of the cartilaginous fishes, are without air-bladders, while most of those which live near the surface of the water are supplied with them. Others on the contrary are supplied with air-bladders which are sacculated, and extend nearly the whole length of the body, precisely like the lungs of the serpent tribe, and the *ductus pneumaticus* which opens into the pharynx, is even surmounted by a perfect glottis, and provided also with muscles to close it. The best example of this kind of air-bladder is found in a fish of the pike kind, named the *Lepidosteus osseus*. It inhabits some of the rivers in the interior of North America, and is the only living representative of a long-lost family of bony-scaled fishes. Professor Agassiz, in dissecting one of these fish, was immediately struck with the great analogy between its air-bladder and the lung of a serpent; and this organ has also been made the subject of a paper in

Müller's Archives, by Professor J. Van der Hoeven. The Lepidosiren, too, the real ichthyic character of which has been so ably demonstrated by Professor Owen, in a late part of the 'Linnean Transactions,' is provided with a double sacculated air-bladder, precisely similar to the lungs of some of the Reptilia, and with a glottis as well.

That the air-bladder performs, in some fishes, some other function than that of a float, by the compression or dilatation of which, as in the philosophical toy termed the hydrostatic paradox, it may sink to a greater depth or rise to the surface of the water, must, I think, be allowed. Our countryman, Needham, in his work entitled 'Disquisitio Anatomica,' published in 1667, is one of the first to venture this opinion. He not only figures accurately the air-bladders in four different kinds of fish, but represents the blood-vessels in two of them; and in the eel the two glandular bodies are shown, and the large vessels going to and from them. He however makes no mention of the minute arrangement of the blood-vessels, the only vessels he figures being the large artery seen in the upper compartment.

I will now, in conclusion, state briefly the chief points of interest which may be deduced from my own observations, and what I have been able to collect from the writings of others. The air contained in the interior of the bladder has been analysed with particular care by Priestly, Fourcroy, Configliachi and Biot, as well as by some of the most distinguished chemists of the present age, and they all agree in these points, that in those fish with closed air-bladders, a great proportion of it consists of oxygen, as much as from 69 to 87 per cent., whilst in those fishes in which there is a *ductus pneumaticus*, as in the carp, nitrogen abounds, to as much as 87 per cent., whilst the oxygen and carbonic acid were only about 7 and 5 per cent. respectively. It has been before stated, that in all the closed air-bladders the glandular body is found, and hence we have a right to infer, that this difference in the component parts of the air may be dependent upon this vascular apparatus; besides, all these fish live, for the most part, in deep water, and the bladder is thick and muscular, whilst those with a duct live nearer the surface, and in them it is thin and weak, and the probable use of the gland may be not to secrete air, but to keep what is contained in the bladder quite pure, as these fish, from having no duct of communication, cannot change the air should it become impure; besides, in these thick muscular bladders, we cannot imagine that any interchange can take place between the air in the bladder, and what is contained in the abdominal cavity by endos-

mose or exosmose; and, as there has yet been no external opening discovered, it seems difficult to comprehend what can become of the air which is constantly being secreted by the gland. It would be much more reasonable to suppose that this so called gland should be subservient to the function of purification of the blood, or of the air, than in that of secretion, and that the accomplishment of this purpose may be the reverse of what it is in the lungs of Mammalia; that is, instead of the air being brought in contact with the blood, the blood in the gland is brought in contact with the air. An arrangement of parallel vessels, similar to those in the glandular bodies of the eel and cod, have been found in the choroid gland of the eye of fishes, and also on a large scale, forming two large glands, near the liver of the tunny. We can hardly imagine that these glands, so placed, are for the secretion of air. When the circulation of fishes is taken into account, when the power which impels the blood through the *aorta* is merely the *vis a tergo*, it would not be difficult to suppose that these glands are so arranged, that, instead of the blood of these particular organs going at once back to the gills to be purified, this necessary change is accomplished by the minute division of the capillaries of these glands. That the air-bladder does act as a float in some fish may be true; but if it be punctured, the fish is not deprived of the power of raising itself in the water, as many have supposed, for numerous experiments have been made, which are conclusive as to this point. But the best of all evidence is to be derived from the arrangement of the blood-vessels, which appear to have been overlooked. On a careful comparison of the minute ramifications of the capillary vessels in the air-bladder of the eel with those of other injected tissues in my own possession, and also with those depicted in works on microscopic anatomy, I find that the arrangement comes nearest that of the lungs of reptiles, where a single vessel gives off or divides into a great number of equal sized branches. In the toad, frog, and snake, the only difference to be observed is, that the hexagonal spaces between the capillaries are rather more uniform, and much smaller in size, than in the eel; but this may be accounted for, in some measure, by the manner in which the object has been prepared, as in drying, the membrane has been stretched in one way more than another, so that the hexagons have given place to elongated spaces, but the chief difference is on account of the interior not being divided into cells, as in those of the *Reptilia*. In some air-bladders, and even in the lower or posterior compartment of the air-bladder of the eel, there is an arrangement of wavy vessels, very analogous to

those seen in the *allantois* of the frog. Now, the *allantois* in this animal, like the same membrane in the incubated egg, is now allowed to perform a respiratory office, and this was first described by Townson, in his work entitled 'De Amphibiis,' which was published more than half a century ago; so that in one and the same animal we have two structures exhibiting an analogy in the arrangement of their vessels to two others, whose true functions are known. On exhibiting one of these preparations to my friend Mr. Dalrymple, he at once pronounced that the vessels approached more nearly to the distribution in the cellular lungs of reptiles, than to any other structure that he was acquainted with; and it is more than probable, if the air-bladder of the *Lepidosteus* before alluded to, were injected, that the analogy would be so striking, that it would be difficult to determine which was air-bladder and which lung. There are many other fish which have air-bladders equally interesting, in their stomachs, and which approach very nearly the cellular lungs of the Reptilia. I may notice, besides the *Lepidosiren* and *Lepidosteus*, that of the *Silurus felis*, which is sacculated like the lung of a frog. A figure has been given of this air-bladder by Cuvier, in his 'Comparative Anatomy.'

From the present state of our knowledge, it is difficult to say why the air-bladder should be absent in so many species of the finny race, and present in others. It would require a most rigid examination into the intimate structure and habits of those fish that are not supplied with this organ, to answer this question: it will, no doubt, be found eventually, that there is some arrangement either in the gills, or some other part of their system, to compensate for this loss, and, at the same time, prove the unity of the plan on which all these remarkable animals are constructed.

Since writing the above, I have succeeded in injecting the lungs of the chameleon, and in this animal the arrangement comes nearest that found in the upper compartment of the air-bladder of the eel, the only differences being, that in the chameleon the capillaries are much smaller, and the formation of the meshes more angular, than in the eel, as seen in figs. 1 and 6 (Pl. xii.), as compared with fig. 2. In other respects they are perfectly identical. I may here also state, that at Professor Owen's request, I succeeded in injecting a small portion of the air-bladder of the *Lepidosiren*, and the arrangement of the vessels was precisely like that of the lungs of the Reptilia.

July 19, 1842.

EXPLANATION OF PLATE XII.

Fig. 1. A portion of the lower part of the lung of a Chameleon, exhibiting the arrangement of the capillary blood-vessels.

Fig. 2. The blood-vessels of the upper compartment of the air-bladder of the Eel.

Fig. 3. The blood-vessels of the interior of the air-bladder of the Cod-fish, *(Gadus morrhua)*.

Fig. 4. The blood-vessels of the lower compartment of the air-bladder of the Eel.

Fig. 5. The parallel arrangement of the blood-vessels in the interior of the air-bladder of the Pike, *(Esox lucius)*.

Fig. 6. The vessels of the lower part of the lung of the Chameleon, (part of fig. 1), magnified fifty diameters, showing the similarity of arrangement between them and those of the Eel in fig. 2.

EXPLANATION OF PLATE XIII.

Fig. 1. The air-bladder of the Eel, natural size.

a. Upper compartment.

b. Lower compartment.

c. The opening of the upper compartment, as seen in the pharynx.

d. The two glandular bodies.

Fig. 2. The arrangement of the vessels in one of the glandular bodies, (magnified twenty diameters).

Fig. 3. One of the glandular appendages to the large trunks in the gland of the air-bladder of the Cod-fish.

a. Looped termination of the capillaries.

Fig. 4. A cluster of the same, in various positions, exhibiting the looped termination of the vessels.

XVII. — *On the Structure of the Animal Basis of the common Egg-shell, and of the Membrane surrounding the Albumen.* By WILLIAM B. CARPENTER, M.D.

Read October 19, 1842.

THE enclosed preparation consists of some portions of the membrane of the egg-shell, decalcified by dilute acid, and of the *membrana putaminis.* They all have exactly the same structure, and differ only in thickness. The thinnest laminæ are seen to possess a beautiful structure, composed of interlacing fibres, between which numerous interspaces are left. I have not been able to ascertain the number of such laminæ, which together make up the shell-membrane and the *membrana putaminis ;* but it must be very considerable.

The natural *uncalcified* membrane of the "egg without shell," presents (as might be expected) exactly the same appearance as the *decalcified* shell.

The deposit of calcareous matter probably takes place in the interspaces left by the reticulation of the fibres. In the common hen's egg, it certainly has a *chalky* character. It is so opaque that I have not been able to reduce the shell thin enough to see light through it. It would be interesting to see how far this structure might be modified in those eggs that have been said to have a crystalline fracture; (see 'Microscopic Journal,' i. 181).

The easiest way to obtain a layer of this fibrous membrane, is to put a piece of egg-shell (freed from the *membrana putaminis*) into dilute acid; in a short time, a very delicate pellicle may be seen on its internal surface, which may be readily detached. In this layer some bodies may be generally detected, about the size of blood-corpuscles, and having a granulated appearance when they are seen without the covering of fibrous membrane, which usually renders them indistinct. Some of them may be observed in one of the portions of the enclosed preparation.

I am strongly inclined to believe, that this membrane is to be regarded as analogous to the chorion of Mammalia; and that it is formed in the mode in which Dr. Barry has described that membrane to be produced, namely, by the deposition of blood-corpuscles on the *ovum* from the inner surface of the oviduct; and the subsequent conversion of these into a fibrous tissue. Dr. Barry (to whom I have shown these preparations) sees his double spiral in some of the fibres; but this I have not been able to recognize.

The purpose of this interesting structure is evidently to allow free passage to *gases* through the shell and the *membrana putaminis*, whilst *liquids* are effectually retained by it.

I make this brief communication, because I am desirous of putting upon record, without delay, an interesting fact which I believe to be hitherto unknown; and of suggesting to some other microscopists to carry out the enquiry,—my own attention being at present differently occupied.

Bristol, September 19, 1842.

XVIII. — *An explanation of the cause of the Rapid Decay of many Fruits, more especially of those of the Apple and Peach Tribes.* By Arthur Hill Hassall, Esq.

Read October 19, 1842.

I know not whether the cause of the rapid decay of fruits, more especially of those of the apple tribe, which I am about to relate, has been ere this promulgated or not, but the discovery is, I fear, of too interesting a nature, and one moreover so easily made, that I cannot be the only fortunate observer of it. As it may, nevertheless, be otherwise, I shall proceed to detail the particulars, trusting that I may succeed in imparting to my hearers some portion of the pleasure and interest which I myself experienced on making the observations.

Before submitting any portion of decayed fruit to the microscope, by means of which many achievments in natural science have already been effected, and to the number of the triumphs of which the present discovery must be added, I observed that the soundest and finest fruit was affected almost as frequently as that of an opposite description; and that the process of decay did not commence in any one particular situation, beginning as often near the base as the apex of the affected fruit; but that its direction was determined by some bruise or injury which it had received. From these general remarks I was led to conclude that the cause of the decay, whatever it might be, was not of a constitutional but of a local character. With a view therefore of ascertaining the nature of the cause, I placed a portion of decayed apple upon the field of the microscope, and was much surprized to observe vast numbers of ramified filaments, passing between and around the cells of the parenchyma in all directions. Here, then, I at once perceived that a satisfactory explanation was afforded of the phenomenon of the decay of fruits; that is, supposing the presence of the filaments to be constant. The ramified filaments were to be regarded as those of a minute *Fungus* or *Fungi*, which, by insinuating themselves between the cells of the pulp of the fruit, detached them from their connexion with each other, thus producing a chain of effects, as follow.

The relation of the cells being disturbed, the process of endosmosis can no longer be carried on, and the circulation through the fruit becomes, as a consequence, either enfeebled or destroyed. The cells

being isolated and detached, and the circulation through them interrupted or altogether annihilated, they are now unable to maintain an independent existence, and their vitality becoming enfeebled, the laws of chemical affinity are called into operation; gases are generated in the interior of the cells, finally producing their rupture and a decomposition of their contents. Thus, therefore, by the simple and mechanical operation of the *Fungus* alluded to, is the destruction of the fruit insured, and a satisfactory explanation afforded of the rapid decay of certain fruits.

But it may be asked, is not the *Fungus* to which allusion has been made, an effect and not a cause of the decay? I am of opinion, for reasons presently to be stated, that it cannot be regarded in any other light than as a cause; not the only one, indeed, but as the principal and exciting cause of the phenomena of the decay of fruits.

All the causes, for there are several minor ones which concur in producing decay in fruits, may be divided into the predisposing, the exciting and the proximate. Among the predisposing causes may be mentioned imperfect development of the fruit; an over ripe state; a lax condition of the parenchyma or pulp; and exposure to extremes of temperature combined with moisture. The exciting causes are injuries, bruises or contusions, but above all, the *Fungus* or *Fungi* spoken of: while the immediate cause is impeded circulation, which brings with it the results above detailed.

It will now be apparent that a marked analogy exists between mortification occurring in the animal frame, and that form of decay in fruits arising from the presence of a fungoid production, which form may, indeed, with propriety, be termed vegetable mortification. The causes of mortification in the animal, as well as in the apple, pear and numerous other fruits, resolve themselves into predisposing, exciting and proximate — the predisposing being peculiar habits and conditions of body; the exciting, injuries and exposure to extremes of temperature; and the proximate, interrupted circulation. The only difference in the two forms of mortification, consists in the manner in which the circulation becomes affected in each: in the animal form, it is the result of a vital process, inflammation and its consequences, while in the vegetable form, it is the effect of the operation of a mechanical cause, or impediment to the circulation arising from the presence of the *Fungus*.

In order to show how far the presence of the *Fungus* is necessary for the production of decay in fruits, let us endeavour to explain the phenomenon without reference to it.

I have said that the decay affected the soundest and finest fruit, as well as that of an opposite description; and from this I concluded that the cause, whatever it might be, was of a local and not of a constitutional character. The supposition, therefore, that the decay, in those instances in which it occurs in sound fruit, arose from enfeebled vitality of the whole fruit affected, would not afford a satisfactory explanation. Since if that were the case, every part of a fruit, an apple or pear for example, about to pass to decay, ought to be equally and simultaneously attacked. Neither would the opinion that the decay was the result of diminished vital energy in the bruised or injured portion of the fruit, be any more satisfactory, unless it were argued that fruits were subject to an inflammatory process, for how otherwise could the extension of the decay to the sound portion of the fruit be accounted for? But a third attempt at an explanation may be made, on the ground that atmospheric air enters more readily into the bruised portion of the fruit, and that its oxygen, combining with the elements of the contents of the injured cells, forms deleterious compounds which effect the decomposition of the sound portion. But the falsity of this view is easily proved by the fact that it is rather unfavourable to the form of decomposition here spoken of, as may be demonstrated by a simple experiment. If apples divided with a knife be exposed to the air, together with such as are bruised, the skin not being ruptured, the decay of the bruised part will result more quickly than that of the simply incised fruit.

Seeing therefore the deficiencies of the only explanations which it appears to me could be suggested of the particular form of decay which so generally affects fruits of the apple and peach tribes, I am compelled therefore to have recourse, for a consistent explanation, to the *Fungus* which I have this evening introduced to the notice of the Members of the Microscopical Society.

But it must not be supposed that I am going to deny the possibility of an apple passing to decay in the same manner as other organized substances, whether animal or vegetable, namely, by the laws of chemical action operating upon their substances, the animating principle having fled from its temporary tenement; but the decay, the result of a general loss of vitality, is very different from the form of decay which has this evening been discussed, which may have, and frequently has, its seat in the fruit while it is still upon the tree, firm, juicy and life-like.

Liebig, in his philosophic work on Organic Chemistry, divides the processes of organic decomposition into those of fermentation, putre-

faction and decay; to the last of these he applies the term *cremacausis:* and he accounts for its extension from one portion of a body to another part of the same, or to a neighbouring body, by reference to a remarkable principle, the exact method of the operation of which is however by no means clear, that substances, while undergoing decomposition, cause other bodies with which they are in contact likewise to become decomposed; and this, not by virtue of any chemical action which the decomposing body exerts on that, the decomposition of which it effects, but by a kind of induction. As, however, the processes here mentioned affect only dead organic matter, the principle therefore, so elaborately illustrated by Liebig, does not appear to me to be in any way concerned in occasioning the extension of that peculiar form of decay, the subject of the present paper, and which I have stated to involve sound and living portions of fruit. Were however any one of the processes above referred to applicable to it, still, the influence exerted by the *Fungi* in effecting the decomposition and destruction of fruit, would be in no way lessened or disproved.

The rapidity of the extension of vegetable mortification depends upon three causes, which I have denominated predisposing; viz., an over-ripe condition of the fruit; extremes of temperature combined with moisture, (the effect of which may be seen in apples that have been allowed to remain for a few days upon a lawn in autumn); and lastly, a loose aggregation of the cells of the parenchyma: fruit so predisposed passing to decay much more rapidly than such as is of an opposite nature. Thus the firm hard apple, in which the cells are closely compressed, opposes much more resistance to its progress, nor is it so readily subject to its influence.

Let us now examine the *Fungus*, or rather, I should say, *Fungi*, for several species concur frequently in producing the same phenomenon. Two of these I have succeeded in tracing through several stages of their development. In the earliest state in which I have noticed them they consist of innumerable ramified filaments, of extreme minuteness (*thallus*), which, when closely examined, appear to be annulated within the outer sheath, so as to convey the impression that they are in reality *Confervæ* and not *Fungi*, a view which I should unhesitatingly have adopted, had I not succeeded in tracing the development of these annulated filaments further. In the second stage of their growth, the filaments are seen to have undergone a considerable increase in size, and the *annuli* are no longer visible. In the next epoch of their development, the ramified filaments (*thallus*) may be observed to take their origin from the lower portion of a filament

much longer than any of the others, and which is, in fact, to be regarded as the stem of the plant, of which there are usually many thousands in a single decayed apple or pear. During these three stages of their growth, the *Fungi* are wholly within the body or mesocarp of the fruit, and have usually no direct communication with the external atmospheric air, from which they are separated by the epicarp or skin; but in their fourth and final condition, a portion of each *Fungus* becomes external, and they can only become so when either the skin has been ruptured by violence, or deteriorated by the process of decomposition. This external portion is the proper plant, and consists of a long stem, bearing at its extremity the reproductive portion of the plant, which assumes various forms indicative of the species. The ramified filaments therefore, which are the first parts formed, are the roots, or organs of nutrition of the *Fungi*. Now, I have no doubt whatever, that the external portions of the majority of those *Fungi* which develope themselves on the surface of fruits, have been figured and described; but their internal relations and effects, so far as I am aware, have escaped notice: and these appear to me to be exceedingly interesting.

Two enquiries of much interest still demand our consideration: — the first relates to the manner of the entrance of the *Fungi* within the fruit; the second, to the cause which determines the precise period of their development.

There are two ways in which I conceive it possible that the sporules of the *Fungi* might have gained admission into the fruit, or, what is nearly the same thing, into the fruit-tree: — either by the stomata on the surface of the fruit and plant; or by means of the roots, the soil containing the reproductive bodies, the presence of which in it being accounted for by the decay of fruit on the earth beneath the tree.

The causes which determine the precise period of the development of the *Fungi*, are involved in mystery almost as impenetrable as those which regulate their reproduction. They would appear, however, to be, — injury to the fruit, its condition, and variations of temperature, especially combined with moisture; the latter being a predisposing, and the two former, exciting causes of development: although the exact manner in which injury to fruit acts, as such, is not very clear, but is possibly thus. The injury to the fruit occasions the rupture of some of the cells of the parenchyma, and the effusion of their contents; a decomposition is brought about, amidst which the *Fungi* find the combination of circumstances essential to their growth and sustenance.

Whether the explanations offered of the mode of entrance of the *Fungus* within the fruit, and of the causes of its developing itself cotemporaneously with injury, shall be deemed satisfactory or not, I cannot say; but I would utterly repudiate the doctrine of spontaneous generation, as affording any solution of the difficulty. Because I cannot offer rational explanations of certain phenomena, shall I content myself with such an irrational and irreligious theory as that which supposes that inert and unorganized atoms can endow themselves with organization, the most complex, form, the most beautiful, adaptation the most perfect? — and further, that when they have done these things, they can bestow upon themselves motion, and that vital breath which God himself is declared to have breathed into the nostrils of man? Surely not!

Further Observations upon the decay of Fruits, more especially of such as belong to the Apple and Peach tribes. By ARTHUR HILL HASSALL, Esq.

Read November 16, 1842.

IN the paper which I had the honour of reading to the Microscopic Society, at their last meeting, entitled 'An Explanation of the causes of the rapid decay of many fruits, more especially of those of the Apple and Peach tribes,' the question was raised, whether the *Fungi*, the presence of which in decayed fruits the microscope reveals, were to be regarded as a cause of the decay, or only an effect; and it was concluded, mainly from the circumstance of the decay attacking sound fruit, in which the vital principle was strong, and which, therefore, could not be the subjects of any known law of chemical decomposition, that they were not the effect, but a cause, the chief one, indeed, of that peculiar form of decay to which fruits are liable, and which so speedily brings about their entire destruction.

Satisfactory as this explanation doubtless is, that the decay originates in the growth of the *Fungi*, I now wish to bring forward still more conclusive evidence of the influence exercised by the *Fungi* in producing decay, and this, too, of a nature which all will at once be able fully to appreciate, as it consists in the fact of the decay being communicable, at will, to any fruits of the apple and peach kind, no matter how strong their vital energies may be, by the simple act of

inoculation of the sound fruit with a portion of decayed matter, containing filaments of the *Fungi*.

Although it might safely be concluded, by the light of reason, that if the *Fungi* were really the cause of the decay, they would reproduce this decay, when introduced into sound fruit; — yet I was hardly prepared for the marked and rapid changes which fruit thus inoculated undergoes. In twenty-four hours from the introduction of the decayed matter, if the apple or pear employed in the experiment be at all of a soft consistence, the effects become manifest; a softness and discolouration taking place around the spot which contains the decayed fruit, mixed up with minute filaments of the *Fungi;* and this softening and discolouration will often extend, in the course of three or four days, over more than an inch of the circumference of the apple or pear, progressing unceasingly until it has involved the entire fabric, the decay developing itself in exact correspondence with the growth of the fungi, so that in a few days, or weeks, a complete disorganization of the fruit is effected by the silent and unperceived operation of an agent, apparently weak and insignificant, but which annually destroys vast quantities of various descriptions of fruit.

It signifies but little what be the decayed matter used for this inoculation, provided the filaments of the *Fungi* be present in it. So that if we inoculate an apple with a portion of decayed pear, the result of the experiment will be the same as it would have been had the decayed material been of the same nature as the fruit inoculated; and we may use with success the sporules of such *Fungi* as are observed to develope themselves on the surface of injured fruit, but in this case, the decomposition does not set in so quickly, requiring many days to elapse before any very decided change is visible. In order to ensure the success of the trial of inoculation, it is advisable to raise lightly the epidermis of the fruit, the subject of the experiment, and remove a small portion of the parenchyma, supplying its place with the decayed matter.

In the communication already referred to, it was suggested that the sporules of the *Fungi* might have entered the fruit, either by the stomata on its surface, as well as those of the tree generally; or, by the termination of the root, the soil containing the reproductive bodies. It is manifest, however, from the fact that a simple bruise, which does not impair the integrity of the epidermis of the fruit, has, but in one instance in which I have made trial, given rise to decay; and that sound fruit, the cuticle of which *has been ruptured*, if kept from decayed fruit, is long in becoming affected, while that which is placed

near affected fruit soon becomes similarly involved: that the entrance of the sporules of the *Fungi* is generally, if not always, through the ruptured epidermis. However, I am not inclined at present to discard the notion of the entrance of the sporules by the stomata and spongioles.

A gentleman asked me, at the last meeting of the Society, if I could inform him of any plan by which the decay of fruit could be prevented; and the only reply which I was then able to make was, that I had hitherto thought only of the cause of the disease, but that the next thing would be to seek for a remedy. I believe that I can now, however, give a more definite answer to the question; for I consider that any preparation, so covering the surface of the fruit as to exclude it from contact with the atmosphere, would prevent the development of the *Fungi*, and the preparations which I would recommend for this purpose, are solutions of shell lac, sealing-wax, or mastich in spirits, or a compound of shell lac, borax and water, the proportions being, of water, 1 lb., shell lac, ½ lb., and borax, 2 ounces.

In support of this statement, I would refer to the well-known facts of the impossibility of decomposition taking place, or vitality existing, without the influence of an atmosphere of some kind or other; and that at least one of the preparations above referred to does protect the surfaces of fruit from the atmosphere, we have practical evidence in one of the apples now before us. This apple was first covered with a varnish of sealing-wax, and subsequently inoculated, but the innoculated spot, be it observed, has not gone on spreading with one-tenth the rapidity with which it would have done, had the apple not been thus coated. It is probable that very many weeks will elapse before the *Fungi* entirely destroy this fruit, if they even then accomplish this end.

The carrying into effect of any one of the processes above referred to, would certainly be attended with some expense and trouble, but this, in the case of valuable dessert fruit, would be a consideration of but little consequence; and I do not doubt that some less expensive preparations might be thought of, which would answer the purpose equally well. It might be worth while to make trial of lime for the preservation of fruit; the apples or pears being placed in boxes filled with it. My present object, however, is to dwell chiefly upon the condition necessary to effect the preservation of fruit, viz. the exclusion of air; for this being clearly understood, the means of doing so are more likely to follow as a result.

Expressing a hope that, at least, one of the plans suggested may be found to answer the end in view, of saving the vast amount of fruit annually destroyed by the *Fungi*, I take my leave of a subject which, if it be attended with no other result, has, at least, afforded me very much pleasure in the investigation; some portion of which I have endeavoured to communicate to the members of the Microscopic Society.

Observations on the production of Decay in Fruit, by means of Fungi—continued. By ARTHUR HILL HASSALL, Esq.

Read December, 1842.

BUT few persons, I imagine, who have given the statements already adduced an attentive consideration, will be disposed to question the power possessed by several species of *Fungi* of originating decay in fruit. Should there however be such persons, the fact that decomposition may be produced by the introduction of *Fungi* into apples while growing upon the tree, and still the recipients of its nutritive sap, must be sufficient to convince even those of the extraordinary and independent influence exerted by various *Fungi* in occasioning decay in sound and living fruits.

The experiment of inoculating fruit, while it maintains its vital connexion with the tree, which may be regarded as the *experimentum crucis*—the test and crowning proof of the power of these atoms of creation in destroying fruit,—has proved as successful, and its influence as marked, as in my former paper I stated inoculation to have been in fruit removed from the tree; the only effect which the greater firmness and vitality possessed by the fruit upon the tree seems to produce, is that, perhaps, of slightly retarding the progress of the decomposition.

In a paper read at the last meeting of the Society, it was stated that decay might be produced in sound fruit, at will, in two ways; either by the introduction of the filaments of the *Fungi* contained in most decayed fruit, or by means of the sporules themselves; but that when the latter were introduced, a much longer time was requisite for the development of the effect of the inoculation, than was required by the filaments, and this for an obvious reason: in the one case the smaller filaments of the *Fungi* have advanced several stages in their growth, while in the other, the sporules have yet to pass through the several stages of development. Now, decay likewise takes place *naturally* in these two ways, but the filaments, however, require to

be in *actual contact* with the sound fruit, in order to occasion its contamination, which they must do by penetrating through the cuticle, which thus appears to be an inadequate provision for the protection of fruit from the inroads of these insidious destroyers; whereas it is not necessary for the sporules to be placed in contact with the fruit, for they can act, in producing decay, at a considerable distance from their source, the atmosphere being the medium of their dissemination.

In a practical point of view, it is useful to bear in mind this distinction, for it affords an explanation of the reason why apples, and other fruit, when not allowed to touch each other, become affected with decay, more than when heaped up. Experience has long taught the wisdom of this practice, although but few, if any, could have explained from what cause its beneficial results proceeded.

In the paper already referred to, it is stated, that it was conceived that the introduction of the *Fungi* very generally, if not always, took place through the ruptured cuticle. I am now, however, certain, that they find admittance, in many cases, where no rupture or disorganization of the skin can be discerned; but the way in which they do so is not very clear, though probably it is by insinuating themselves between the cells of which the cuticle is composed, or, perhaps, by means of the *stomata*, where they are present; but, as far as I can ascertain, these organs are but rarely, if ever, present on the surface of the fruit. If they are ever present, the sporules, without doubt, from their excessive minuteness, could readily obtain admission through these natural apertures.

I have here an apple, the history of which is peculiar. Some time since a portion of the parenchyma was purposely bruised, without any rupture of the cuticle being permitted, in order to ascertain whether this treatment would give rise to decay. It did not, however; and many weeks afterwards an opening was made through the skin into the bruised portion of the fruit, and the apple allowed to remain for a few minutes in the neighbourhood of other fruit affected with decay; it was then placed beneath a small glass jar, under which it remained until disturbed for the purpose of being exhibited to the Society. Its structure is now wholly disorganized, and its surface covered with two species of *Fungi*, belonging, probably, to different genera; the one of which has made its way to the interior of the fruit, principally through the opening purposely made; the other, however, has made many openings for itself.

I may observe, in conclusion, that the peculiar softening and discolouration which it is well known medlars undergo, before they are

considered fit for the table, is, as I have ascertained by microscopic examination, to be regarded, as Dr. Lindley has suggested was probably the case, as an instance of true decomposition from chemical causes; while, on the other hand, I strongly suspect, that the rapid decay which the orange, lemon, &c. frequently undergo, is the result of the operation of minute *Fungi*.

Some further Observations on the Decay of Fruit.

By Arthur Hill Hassall, Esq.

Read April 19, 1843.

In the first paper in which I introduced to the notice of the Society the subject of decay in fruit, I endeavoured to explain the phenomena of that form of decay to which fruit is so liable, without reference to the *Fungi* which I regard as originating that peculiar form; and I did so, first, by a consideration of the well-known principle, that a body in the act of decomposition is capable of communicating, by a kind of induction, decomposition to other bodies with which it is in contact, a principle which Liebig has elaborately illustrated, and adopted to explain the various phenomena of fermentation and decomposition, but which I considered to be inapplicable to the general form of decomposition occurring in fruit, principally from the circumstance of its attacking fruit when in a highly vital condition, and when, as a consequence, it could not be supposed to be the subject of any spontaneous or chemical disorganization.

Dr. Lankester, however, at the last meeting of the Society, seemed to consider that Liebig's views did afford a sufficient explanation of every example of decay occurring in fruit; and he stated in support of these views, that an apple, once removed from the tree, was no longer to be regarded as in a vital state, but that it immediately became subject to a species of fermentation. Now I know not what may be the authority for this statement, but I cannot help doubting its accuracy, since it is possible to preserve fruit free from all *visible deterioration, for many months* after its removal from the tree. However, for the sake of argument, supposing this, as well as Liebig's views, to be correct, neither would account for decomposition induced by the introduction of the filaments of the *Fungi* contained in decayed matter, while the fruit maintained its connexion with the tree, and respecting the vitality of which there could be no second opinion: nor would they explain the reason why decay commences in a spot,

which gradually extends itself over the surface of the fruit, and does not at once involve its entire substance and fabric. All that Liebig's theory can do, is to supply an explanation of the cause of the extension of decay after the *direct* introduction of decayed matter; and this only provided the fruit inoculated no longer possessed vitality.

I showed also in the communication referred to, that the mere bruising of the parenchyma of the fruit, or its exposure to the contact of air, would not in itself give rise to decay; and thus, having been unable able to find any sufficient cause which would explain all the phenomena of decay in fruit, I was then compelled, as I am at present, to have recourse for a satisfactory explanation to the operation of entophytal *Fungi*. At the same time, I fully recognized the existence of a second form of decomposition in fruit, this being comparatively of rare occurrence, and the result of the operation of chemical affinities, vitality having ceased. To this form the views of Liebig may, perhaps, with propriety, be applied in some cases.

Since the last meeting of the Society, I have repeated the experiment of inoculating fruit with the sporules of the *Fungi*, and with the same success which attended the former experiment; but I have failed in inducing decay in sound fruit, by the introduction of decayed matter destitute of *Fungi* in any state. Not, however, but that this effect *might* ensue in some cases in which the vitality of the fruit was either totally destroyed, or at all events much enfeebled; but were it an invariable consequence of its introduction, this would not in any way affect the truth of the statement made relative to the independent power possessed by *Fungi* in originating decay: and even if they were proved not to do this, they would still be of as much importance in a practical point of view as ever, since when inserted into fruit which is undergoing spontaneous decay, these insidious destroyers will produce marked and rapid effects, and speedily ensure its complete destruction.

In conclusion I may state that the apples employed in the two experiments were of an exceedingly firm description; and that an equal number was inoculated with the sporules and with decayed matter.*

* In the 'Annals and Mag. of Natural History' some further observations will be found in proof of the powers possessed by Fungi in destroying the living and *healthy* vegetable fabric. In this communication it is stated that the "thallus" of a minute Fungus was introduced into different portions of various kinds of vegetables, in all of which decay was induced by its development, the extent of injury being greater or less according as the plant subjected to the experiment was of a cellular structure, or otherwise.

XIX. — *On the Structure of the Shells of Molluscous and Conchiferous Animals.* By J. S. Bowerbank, Esq., F.R.S., &c.

Read January 18, and November 15, 1843.

The results arising from an examination of the organic tissues of the Corallidæ, published in the 'Philosophical Transactions,' part 2, 1842, p. 215, suggested to me the idea of pursuing a similar course of researches into the nature and origin of the testaceous coverings of molluscous and conchiferous animals, in the hope of being able, in some slight degree, to add to the present amount of knowledge of the origin and development of these curious animal structures. The existence of organic cells and vessels in the tissues of the Spongiadæ, and in the bony skeletons of the Corallidæ, naturally induced a belief that in the testaceous coverings of the still higher classes of organized beings, these primary organic tissues would be developed in a more marked and determined form, and that it might eventually prove that the ingenious doctrine of the origin and mode of increase of shells, — first promulgated by Reaumur, and adopted by a great majority of subsequent naturalists up to the present time,—would be found in some degree incorrect, and that instead of being excrementitious, unorganized and crystallized bodies, we should find the origin of these parts of the animal, and their mode of increment, to be in accordance with those laws of vital origin and increase which are so beautifully developed, by the aid of the microscope, in the bony skeletons of animals both above and below them in the chain of created beings. With these views I commenced my researches, early in the spring of 1842, by a careful examination of the young cartilaginous lips of the common garden-snail (*Helix aspersa*), and subsequently by an examination of the structures of numerous species of adult univalve and bivalve shells, by maceration in weak solutions of hydrochloric acid, and by other modes. I will not trespass upon the patience of my readers by entering upon a minute detail of the facts arising out of each of these examinations, but confine myself to a description of the general results arising from them.

Reaumur, and subsequent writers upon this subject, entertained the idea that the periodical additions to the lips of the shells of land-snails were effected at the will of the animal in the following manner. In the first place, the snail caused an exudation of a thin stratum of coagulable lymph from the surface of its mantle, which, being united

to the edge of the old lip of the shell, and becoming indurated by the action of the air, formed a cartilaginous mould and basis upon which the calcareous matter was to be ultimately deposited. The carbonate of lime thus destined to afford strength and substance to the new shell, it was believed, was secreted in the foot or mantle of the animal, whence it was poured forth, and applied mechanically to the surface of the membrane, layer after layer being thus deposited from within, until the shell became of the required degree of thickness: thus supposing a perfectly mechanical or crystallized arrangement of the earthy matter of the shell. And in the latter of these errors naturalists were confirmed by the Compte de Bournon's investigations of shelly structures, described in the last four chapters of his 'Traité de Mineralogie,' and figured in his plate 1.*

I have not had an opportunity of repeating with sufficient care the observations made by Reaumur upon the animal during the progress of the development of the new lip of the shell, but I believe him to be correct in his description of the first stage of the process, which is quite in accordance with the general views entertained by modern physiologists of the origin and mode of repair of primary membranous tissues. My own observations on the formation of the new lip have been confined to a careful examination of the newly-formed membranes, and the results are as follow.

If the newly-formed lip be carefully removed, so as to include a portion of the shelly matter as well as the membrane, and be put into

* By using an inadequate amount of microscopical power, this learned mineralogist has evidently been induced to believe that the beautiful plates composed of single series of elongated cells, crossing each other at right angles to their respective axes, and which I shall hereafter describe in treating of the structure of the univalves, were the result of crystallization; and under this impression he says, page 310, "Mon but est de faire voir ici, que ce têt appartient exclusivement à la cristallisation de la chaux carbonatée. Que l'animal, par les contours de son corps, et les diverses extensions et courbures de ses membranes, a très probablement déterminé la forme que ce têt présente; mais que, quant à sa nature, c'est un chaux carbonatée simple, cristallisée à l'état lamelleux et par couches, ainsi que celle qui donne naissance aux dépôts cristallins et autres variétés analogues de cette substance. Si on en excepte, en effet, les parties dans lequelles une très-légère dose de gélatine a été placée par l'animal, pour y servir de matière colorante, et y orner, comme telle, la surface d'un très-grand nombre d'entre elles, le reste renferme une dose si foible de cette même gélatine, qu'il doit être regardé comme appartenant à une des variétés les plus pures de la chaux carbonatée: il en existe en réalité bien peu, même parmi les variétés en cristaux transparens et déterminés, qui ne soient mélangées d'une dose plus considérable de substances étrangères."

a little water, covered with a thin slip of glass, and examined by transmitted light with a power of 280 linear, it presents the appearance of a thin, yellow-coloured, horny membrane, thickest at its junction with the old lip of the shell, and becoming gradually thinner towards the outer margin. There are an infinite number of minute globular vesicles scattered over the whole of its surface, which vary in diameter from $\frac{1}{50000}$ to $\frac{1}{3000}$ of an inch, (Pl. xiv. fig. 1). These vesicular bodies are incipient cytoblasts and cells; for, although in the early stage of their growth we cannot discern the nucleus, they may be readily traced through their various stages of development, until in the larger vesicles it may frequently be observed; and the young cells approaching each other are compressed closely together, and become the first superficial layer of cellular structure. It frequently happens that in the process of mounting a piece of the young lip of the shell for examination, a number of the cytoblasts are dislodged from the new membrane. If these be examined with a power of 600 linear, the nucleus is very distinctly to be seen in the greater part of them, and the new cells may be observed in various stages of development, with their accompanying cytoblasts, as represented in Pl. xiv. fig. 3. The completion of the process of the development of the cellular tissue may be best observed in the immediate neighbourhood of the old lip of the shell, and thence gradually towards the outer margin of the newly-formed membrane, they may be seen in all their different stages. While the young cells are detached from each other, and retain their globular forms, they are perfectly transparent, the secretion of calcareous or other matters not appearing to have commenced; but we frequently observe, in the neighbourhood of the newly-formed stratum, small patches of cells congregated together, which are of a deep yellow tinge, and of a semi-opaque appearance, as if they were separate centres of ossification, arising in the same manner that we observe in the production of the calcareous matter in the young cartilages of the bone in the higher classes of the animal kingdom. Amid the great mass of vesicular bodies destined to form the cells for the secretion of the calcareous deposits of the shell, we find other cytoblasts dispersed over all parts of the membrane, which are developed in the form of tessellated cellular structure, by which means the original membrane is very much increased in substance. This production of tessellated cellular structure is more particularly abundant where the calcigerous cells are in their advanced stages of development. If a portion of the newly-formed stratum of shell be removed from the membrane upon which it reposes,

we observe that the horny structure continues to abound in the vesicular bodies in all their earlier stages of growth; from which it would appear that its office is not confined to the production of the first stratum of calcigerous cells only, but that it is destined to originate perhaps the greater part, if not the whole, of the calcigerous cells of the shell, and this appears the more probable, as we may now observe that the membrane has attained a higher stage of organization, minute vascular tissue being frequently observed embedded and ramifying amid its structure, and oftentimes projecting from its torn edges. These vessels are very minute, none of those which I have observed exceeding $\frac{1}{14000}$ of an inch in diameter. If the uncovered portion of the membrane nearest to the old lip of the shell be examined with a power of 500 linear, these minute vessels may be seen in the course of formation, presenting the appearance of long ramifying lines of exceedingly minute gelatinous molecules, closely adhering together in a single series, and frequently appearing cylindrical and tubular in one one part, while in another they have quite a moniliform appearance, (Pl. xiv. figs. 1 & 2, *a*). This production of vascular structure by the arrangement of minute molecules or cytoblasts in single series, I have frequently observed in the membranous tissues of the Corallidæ.* The occurrence of perfectly developed vascular tissue, at the advanced stage of the formation of the new lip of the shell which I have described, is exactly what might have been expected to take place, as, according to the best authorities, cellular cartilage in the higher classes of animals is not penetrated by blood-vessels; but when it has become filled with bony secretions, they are then found permeating its structure in every direction. In a similar manner, in the early stage of development of the shell-structure, we may naturally expect the same law to prevail, and accordingly we find the newly-formed cartilage or membrane of the shell abounding in the rudimentary vesicles of the cytoblasts, while not even a trace or indication of the vascular structure is to be seen in those parts which are nearest to the outer margin of the new lip.

The linear aggregation of cytoblasts, described as producing the minute ramifying vascular tissue, is not the only case of this mode of arrangement which we observe in the young lip of the shell, as we find irregularly dispersed over the surface of the membrane—and frequently floating in the surrounding water in which it has been immersed for examination—cylindrical bodies, of equal diameters in all

* See 'Philosophical Transactions,' part 2, 1842, page 220, pl. 17, fig. 2.

their parts, and composed of a single series of cells, each exhibiting a distinct nucleus or cytoblast, as represented in Pl. xiv. fig. 4. These bodies are $\frac{1}{5000}$ of an inch in diameter, and vary from $\frac{1}{3000}$ to $\frac{1}{200}$ in their length. Upon endeavouring to trace whence these curious bodies came, I found them embedded in bands, corresponding in their direction with the lines of growth of the new lip of the shell, immediately beneath the newly-formed stratum of calcigerous cells, and the direction of the cylindrical bodies, when not disturbed, being in lines, which were diagonals to the lines of growth of the shell, and crossing each other at about right angles, — a mode of disposition which we shall hereafter find to be in accordance with the arrangement of the cellular structure in the adult shells. Amid the layers of well-developed cylindrical bodies, and immersed in the membrane beneath, I observed a number of faint pellucid lines, disposed precisely in the same manner as the distinct and well-developed cylinders, and having every appearance of being the incipient state of those tissues. Upon many of the well-defined cylindrical bodies I frequently observed cytoblasts or cells in progressive stages of development. These additional cells sometimes appear to be irregularly dispersed over the whole surface, but are usually developed upon two sides only, and those opposite to each other. As the tissues which I have described approach maturity, the periostracum, progressively advancing from the old lip, covers the new tissues, and the whole becomes firm and consolidated like the older portions of the shell.

From a careful examination of many new lips in various stages of progressive development, I do not think that the whole of the coagulable lymph, of which the new membrane is formed, is exuded from the surface of the animal at one operation, but rather by a series of exudations, each of which emerges from beneath the terminal margin of the last one; for if the membrane be carefully examined from the line of advance of the newly-formed cells towards its extreme edge, it will be seen that there are several lines of thickened tissue, which correspond in distance and appearance with the lines of growth on the old shell; and this is the more probable, as I have observed in young shells which I have taken from their places of hybernation, in November, that the extension of the lip is still going forward, or rather perhaps has been so up to the very period of their retirement for the season.

On proceeding to investigate the structure of adult shells, I selected for examination thirteen specimens, belonging to the eight following genera, — *Cypræa, Conus, Pyrula, Cassis, Ampullaria, Oliva, Voluta*

and *Bulinus*. The whole of these agree in the nature of their structure in the most perfect manner, with the exception of a mode of arrangement which I shall presently describe. Thin sections of univalve shells, made by the lapidary, and examined by transmitted light, afforded so little information that I had immediate recourse to the aid of the Lieberkuhn; and upon examining in this manner surfaces fractured at right angles to the outer and inner planes of the shell, and either parallel or at right angles to the lines of growth, I obtained a very distinct and satisfactory view of the organic structures and their modes of arrangement. I will not particularize the results of the examination of the whole of the thirteen species operated upon, but select for description *Cypræa mauritiana*, which, from the great quantity of colouring matter intermixed with its structures, is the best adapted for examination by the mode I adopted. Upon submitting to examination a surface of this shell, fractured at right angles to the lines of growth, it was found to consist of three distinct strata, uniform in the nature of their structure, but alternating in the mode of their disposition. Each stratum is formed of innumerable plates, composed of elongated, prismatic, cellular structure; each plate consisting of a single series of cells parallel to each other. These plates of cellular structure are disposed alternately in contrary directions, so that each series of cells intersects the one beneath it at nearly right angles, and the whole of them are so disposed that the axes of the cells form angles of about 22 degrees with the upper and under surfaces of the shell, and present the appearance represented in Pl. xv. fig. 1, *a*, as seen with a power of 280 linear, the portion represented being the central and outer layers of the shell. The planes of these plates of prismatic cellular structure are always either as nearly as possible parallel, or at right angles to the lines of growth, and the mode of arrangement is invariable in each separate stratum, and always opposed to that of the stratum either above or below it; so that if the plates of cells in the central stratum be parallel to the lines of growth in the shell, those of the outer and inner strata are at right angles to them. When we view the stratum of plates of prismatic cells, which are disposed at right angles to those I have just described, or view them in an edgewise and endwise direction, they present an appearance remarkably different from that which we have previously described. In this case the whole of the stratum seems to be composed of a series of basaltiform columns, each column having the appearance of being formed of a series of single cells regularly piled upon each other. This arises from the line of fracture passing

in a direction about equally oblique to the planes of the whole of the plates of prismatic cells, (Pl. xv. fig. 1, *b*). From this description of the alternating mode of arrangement of the plates of cells, it will be obvious that if, on examining a shell, we find a section parallel to the lines of growth, with the plates of the central stratum agreeing in their direction with those lines, while those of the outer and inner ones are at right angles to them, we shall find the apparent direction of the plates exactly the reverse in each stratum if we view a second section of the same shell at right angles to the lines of growth. These modes of arrangement of the tissues are invariable in the same species and genus, as far as I have had an opportunity of judging; and it is somewhat remarkable, that of the eight genera examined, four assumed one mode of arrangement and four the other. Thus, upon viewing sections parallel to the lines of growth of the shells, I found that in *Cypræa*, *Cassis*, *Ampullaria* and *Bulinus*, the plates of the outer and inner stratum were parallel to the lines of growth, while those of the central one were at right angles to them. On the contrary, in *Conus*, *Pyrula*, *Oliva* and *Voluta*, the plates of the outer and inner stratum were at right angles to the lines of growth, and those of the central stratum parallel to them. And it is worthy of remark, that the porcellanous shells do not agree in the mode of arrangement of their tissues, as we find *Cypræa* opposed to *Conus*, *Oliva* and *Voluta*, and agreeing with *Cassis*, *Ampullaria* and *Bulinus*.

The production of each stratum appears to be effected in regular succession from the inner surface of the shell. Upon examining a young specimen of *Ampullaria fasciata*, I found that at the extreme margin, and to about the eighth of an inch backward, there was but one stratum of cells, the plates of which were parallel to the lines of growth. At about the eighth of an inch inwards, a new stratum of cells, with plates at right angles to the lines of growth, commenced, and rapidly increased in thickness as it receded from the lip, until, at about half the revolution of a whorl backward, it had attained a thickness equivalent to about one fifth the entire substance of that part of the shell; and at one revolution backward it was very nearly equal in thickness to the layer above it.

There are some discrepances in the relative degrees of thickness of these strata, at different parts of the same shell, which are interesting, and from which it may be inferred that absorption, as well as secretion, probably takes place in these structures according to the necessities of the animal.

Upon measuring the relative degrees of thickness of these strata

at different parts of the same shell, I found the following variations. The thickest part of the stratum of plates near the mouth of the young *Ampullaria*, which were parallel to the lines of growth, may be represented by the figures 25. At half the revolution of a whorl backward, the same stratum was represented by 20, while the new stratum beneath it measured 13; total 33. At a whole revolution backward, the upper stratum measured 18, and the lower, or new one, 20; the older of the two thus appearing to decrease gradually in thickness as the younger grew in substance.

Upon examining, in a like manner, an adult specimen of *Bulinus oblongus*, the proportions of the strata near the lip were as follow:—outer 10, central 14, inner 17; total 41. But at one revolution they were—outer 5, central 5, inner 19; total 29.

In a great many univalves a remarkably rapid absorption of the shell may be observed at about one revolution and a quarter backward from the edge of the lip, and this appears to have been effected in such a manner as generally to leave the involved whorl, where but little strength is required, of a substance not much exceeding that of writing paper. The portion of shell left is that which forms the inner surface; the whole of the outer and central strata, and the outer part of the inner one, being removed. If a piece of this thin shell from a *Conus* be examined by transmitted light, with a power of 280 linear, we obtain a very beautiful view of the elongated prismatic cells, and of the manner in which they frequently unite with each other, as represented by fig. 2, Pl. xv.

In all the recent univalve shells which I have examined, the prismatic cells appear to be filled with a solid mass of carbonate of lime. When they are fractured across their axes, as represented at Pl. xv. fig. 2, *a*, they do not present such surfaces as might naturally be expected from crystallized bodies, but have an uneven, rough, and somewhat spiculated appearance. Upon examining these organs from the inner surface of a fossil (*Voluta nodosa*) from the London clay, I found that when broken at right angles to their axes, they resolved themselves into exceedingly minute fibres, so that each broken end resembled a worn-out camel's-hair pencil. If these pencil-like ends be crushed in a little water, on a slip of glass, and viewed by transmitted light, with a power of 1000 linear, we find innumerable transparent filaments, which appear to have a cylindrical form; but this point cannot be determined with certainty, from their extreme minuteness. They vary in size; but one of about the average dimensions, which I measured, was the $\frac{1}{10000}$ of an inch in diameter, and

many of them were not above half so large. Among these spicular bodies there were small fragments of plates, formed of similar minute fibres, disposed across each other at right angles, so as very much to resemble a piece of fine linen. I could not ascertain whence this curious tissue came, but from its frequent recurrence in the field of the microscope, there can be no doubt of its being a portion of the regular organic tissue of the shell. I have never found more than three strata of plates in any univalve, nor in any part of the same shell, however old or thick it might be. I examined the lip of a *Cassis tuberosum*, which was half an inch in thickness, while the adjoining portions did not exceed one-tenth of an inch in substance. The great thickness of the shelly matter in the lip was produced by the extension of the outer and inner strata, while the intermediate one was but little increased in thickness; and the elongated cells, of which the plates are composed, retained in each stratum their proper directions and modes of arrangement. In another case, at half an inch within the lip of a very thick shell of *Strombus gigas*, although it appeared to the eye as if there were as many as five or six distinct layers of shell, yet, upon examination beneath the microscope, there was but one stratum, exceeding half an inch in thickness, and in this all the plates were parallel to the lines of growth in the shell.

The structures, and their peculiar modes of arrangement, which I have already described, are those which are common to the great mass of univalve shells; but there are other forms of tissue belonging to this division of our subject, to which I must now direct the attention of my readers, and which vary in their characters to so great an extent from the larger number of univalves, and approach in the arrangement of their cells and other tissues so nearly to the majority of bivalve shells, as to render it advisable to treat of their peculiarities at a point in our investigation as it were midway between the two great divisions of our subject. The shells which best illustrate these structural peculiarities are those which belong to the genus *Haliotis*, and the one which I have more particularly made the subject of my researches is *Haliotis rubra* of Lamarck. If we examine a surface fractured at right angles to the inner and outer planes of the shell, as an opaque object, by the aid of the Lieberkuhn, with a power of 300 linear,—whether the fracture be parallel to the lines of growth, or at right angles to them,—we observe no oblique disposition of prismatic cells such as prevails in all the other genera of univalve shells that I have described; but in either case a regular basaltiform columnar arrangement of cells, whose lines of direction are at right angles to the

outer and inner surfaces of the shell. Upon subjecting fragments of the shell to the action of dilute hydrochloric acid, until the whole of the carbonate of lime was removed, I obtained an abundant residuum of animal matter, which consisted of a series of fleshy membranes adhering to each other, and having their planes parallel to the surfaces of the shell. If the dissolution of the shell in the acid and water be stopped when there is but an exceedingly thin plate of it remaining, and the membranous matter in which it is enveloped be carefully removed from the surface by gently rubbing it between the finger and thumb, and it be examined, immersed in water, by transmitted light, with a linear power of 700, it presents the appearance represented at Pl. xvi. fig. 1. The calcigerous cells, filled with carbonate of lime, are observed closely packed together, and in the centre of the area of each we observe an indistinct grouping of points, as if these were the remains of cytoblasts; and this I am the more inclined to believe to be the case, as we observe, although more indistinctly, the same appearances in the animal remains of the cells which are preserved in the fleshy membranes after complete solution of the earthy matter contained in them had been effected by the continued action of the acid. It is not easily to be determined whether this curious appearance within the areas of the cells be due to the presence of cytoblasts, or to other causes, from the extreme minuteness of the cellular tissue, which does not upon an average exceed $\frac{1}{4500}$ of an inch in diameter. Numerous canals are observed traversing amid the cells in every possible direction. Their courses are tortuous, and seldom in a right line for any considerable distance. Sometimes they are seen pursuing their way for a short space parallel to the natural planes of the shell, but they are usually disposed in lines more or less oblique to these surfaces; and, under such circumstances, a section of them at nearly right angles to their axes may be observed in all parts of the fragment of shell under examination, as represented at Pl. xvi. fig. 1, *a a*. The best view of these organs is to be obtained by an examination of the membranous matter of the shell when totally deprived of the carbonate of lime. In this case we observe them permeating the tissues in every direction, and presenting an appearance exceedingly like that of the same description of organs as they exist in the oyster, and which are represented in Pl. xvi. fig. 5. At the first view these canals may readily be mistaken for vessels, as their parietes are lined with a thick coat of gelatinous matter, but which is not always of uniform thickness like the parietes of a true vessel. Upon a careful examination of the undisturbed

parts of the membranes obtained by maceration in acid, I could not detect any portions of the supposed vessels projecting from their surfaces, or floating freely amid the tissues, in the same manner that we may observe so commonly amid the membranes of the Corallidæ when treated in a similar manner. In a single instance, at one of the torn edges of the membranes, I saw a very small piece of the gelatinous tube projecting from the fractured edge; and this fragment presented no clear and definite outline, such as we always find in disengaged vessels, but the same irregular and gelatinous appearance that is seen in these organs when *in situ*. The canals do not preserve the same diameter throughout their courses, but occasionally expand to twice their average dimensions, and again contract to their original size. The diameters of these organs vary from $\frac{1}{6000}$ to $\frac{1}{3000}$ of an inch; and one of the latter size which I measured expanded at one part of its course to $\frac{1}{2000}$ of an inch, but this amount of dilatation is not of frequent occurrence. The thickness of the gelatinous lining in one of the large-sized canals was $\frac{1}{20000}$ of an inch, and in one of the smaller ones $\frac{1}{30000}$ of an inch.

From the whole of the characters presented by these curious canals, I am strongly induced to believe them to be the Haversian canals of the shell. Like the Haversian canals in the bones of the higher classes of animals, they anastomose with each other, and especially in *Ostrea*, which we shall presently describe: their courses are equally tortuous and irregular, and their parietes are both lined with a mucous or gelatinous coat. It is true, the Haversian canals in the bones of man are on an average $\frac{1}{500}$ of an inch in diameter, while those of shells are $\frac{1}{3000}$ or $\frac{1}{6000}$ of an inch; but their diminutive size in the shell is not out of proportion when we consider the difference in the size of the animals. There is another tissue apparent in the structure of this shell, which draws still closer the alliance which exists between it and bone. If we examine the membranous remains by transmitted light, with a linear power of 1000, we find embedded, in the spaces intervening between the sections of the canals, an abundance of the remains of exceedingly minute vessels or elongated cavities, which measured $\frac{1}{20000}$ of an inch in diameter, and which are either the remains of minute inter-cellular vessels, or of cavities analogous to the so-called corpuscular bodies of true bone; and here the discrepancy in the size of the organs is not so great, as one of the smallest of the bone-corpuscles measured $\frac{1}{9340}$ of an inch, while one of the calcigerous tubes radiating from it was $\frac{1}{45450}$ of an inch in diameter.

The structural arrangement in bivalve shells appears to be subject to a greater degree of variation in different genera than we observe to be the case among the univalves.

Modiola papuana, when fractured parallel to the lines of growth, and viewed as an opaque object with a Lieberkuhn, and a power of 150 linear, exhibits, on the interior surface, a thin stratum of columnar basaltiform cells, at right angles to the natural surfaces of the shell, while the upper surface appears dense, uniform, and apparently composed of numerous thin laminæ, parallel to the natural planes of the shell. In a fracture at right angles to the lines of growth, the columnar arrangement could not be distinguished, probably from its being composed of plates of elongated cells having their planes parallel to the fractured surface. In *Arca Noæ*, when fractured parallel to the lines of growth, we observe plates of prismatic cells crossing each other at right angles, and very closely resembling the mode of arrangement of the prismatic cells in the greater number of univalves. On examining *Venus decussata*, I found two distinct modes of arrangement to prevail. From the inner surface towards the outer one about half the substance of the shell is composed of numerous, thin, membranous, and calcareous strata, which exhibit a dense, uniform structure, when fractured either at right angles or parallel to the lines of growth, but which are readily separated by maceration in weak hydrochloric acid. The outer half of the substance of the shell, when fractured in the direction of the lines of growth, presented the appearance of numerous, basaltiform, columnar series of cells. When fractured in a contrary direction, this stratum proved to be composed of plates of elongated prismatic cells, having their planes at right angles to the surfaces of the shell; the lines of cells nearest to the outer surface curving outwards, and those adjoining the inner one curving inwards, so as to form fan-shaped plates of single series of cells, crossing the lines of growth edgewise. This mode of arrangement of the prismatic cells is not peculiar to *Venus*, but is found also in other genera of bivalve shells. In the fragment of a large fossil bivalve, which I took from the gault formation of Eastwear Bay, near Folkestone, I found them in a peculiarly favorable state for examination, as the whole of the piece of shell separated readily into single plates of fan-shaped structure, which exhibited this organization in a very beautiful manner. Upon examining these plates when immersed in water, by transmitted light, with a linear power of 300, I observed that they were furnished with a vast number of canals, which appeared to be of a similar description to those occurring in *Haliotis*, *Ostrea*,

and many other shells. They are in the greatest profusion at the expanded end of the fan-shaped plate, and, towards the extreme edge, are so thickly disposed, and so tortuous in their course, as to render it exceedingly difficult to follow their lines of direction with the eye. At a short distance from the expanded edge of the plate, towards the pointed base, they are less tortuous in their course, are loosely grouped in bundles of three or four together, and approximate towards straight or slightly curved lines, as represented at Pl. xvi. fig. 2, *a a*. They are not continued towards the pointed base more than a fifth or a fourth of the length of the plate, but usually terminate abruptly in a cœcoid form, without the slightest previous diminution of their diameters. They do not often divide or anastomose, excepting near the expanded end of the fan, but at that part of the plate these occurrences are frequent. In the spaces between the bundles of canals, in some of the plates, near the broad end, there are numerous detached groups of convoluted canals, apparently of the same description of organ as the longitudinal bundles, but not emanating from or in any manner connected with them; and in other plates I found another modification of these curious organs, in the form of numerous, short, straight canals, which are disposed at right angles to the longitudinal ones, and, like the convoluted variety, have no connexion with them, as represented at Pl. xvi. fig. 2, *b b*. Upon carefully measuring the canals, I found the longitudinal ones $\frac{1}{14250}$ of an inch in diameter, and the short transverse ones $\frac{1}{25000}$. In *Unio*, when fractured at right angles to the natural planes of the shell, we find immediately beneath the periostracum a thin stratum of large cells, having their axes at right angles to the natural surfaces. Immediately beneath these is a series of thin plates, which pass backwards in a diagonal direction towards the inner surface of the shell, where they terminate. Each of these plates is composed of an infinite number of polygonal tessellated cells, filled with carbonate of lime. The same tessellated cellular structure prevails in *Mytilus*. The cytoblasts may be occasionally observed in the detached cells of both shells, and especially in the latter, when viewed by transmitted light, with a power of 1000 linear. The shells from which I obtained the tessellated cells in the greatest perfection, were the fossil *Unios* from the fresh-water formation of Grays, in Essex, and from specimens of *Mytilus* found in a very recent diluvial deposit at Bracklesham, Sussex. In these the animal matter has been decomposed to such an extent as to leave them in an exceedingly fragile state, and it is from specimens in such a condition that the best idea of the

structure and arrangement of the tissues may be obtained. If we submit the shell of the common edible muscle to the action of dilute hydrochloric acid, we obtain the animal matter in the form of a series of thin membranes loosely adhering together; and in these, with a power of 300 or 400 linear, in many parts of the tissue, we may trace the developmentof the tessellated cells from the cytoblast upwards, until they are seen closely packed together, and only to be distinguished from the membrane, with which they have now become incorporated, by their junctions with each other resembling small patches of reticulated structure.*

In *Pinna* we find another form of cellular tissue, which is perhaps one of the most beautiful and interesting of all the modes of disposition of these organs that can be found within the entire range of conchological science.

If we fracture any tolerably thick species of this genus at right angles to the natural planes of the shell, either parallel to the lines of growth or in an opposite direction, and view the surface thus obtained as an opaque object by the aid of the Lieberkuhn, with a linear power of 150, the structure appears to be entirely composed of elongated prismatic cells, having their axes at right angles to the natural planes of the shell, and looking exceedingly like regular prismatic crystals of carbonate of lime. If we separate these prismatic bodies from each other,—which may be readily done, by very gently striking a fractured edge of *Pinna affinis* from the Bognor rock of the London clay formation, — and view the prisms immersed in water or Canada balsam, by transmitted light, with a power of 500 linear, they assume an appearance which very strongly resembles that of the fasciculi of muscular fibres, where the banded appearance of the sarcolemma is not very strongly marked; as a series of fine striæ is observed, crossing each prism at right angles to its axis, at somewhat unequal distances. These striæ are so fine that it is necessary to inflect the light at right angles to their lines of direction, before they can be

* Mr. Bowman, in his admirable paper on mucous membrane, in the 'Cyclopædia of Anatomy and Physiology,' describes the basement membrane, as displayed in the kidney, as "an extremely thin, transparent and homogeneous lamina, simple and entire, without any aperture or appearance of structure:" he says also, "it readily wrinkles, and such is its tenuity, that it is sometimes only by the folds thus occasioned that it becomes visible at all." This description is perfectly applicable to the basement membranes of the shell tissues, whether they be situated in the periostracum, lining the internal surface of the shell, or distributed in repeated laminæ throughout its substance.

distinctly seen. In one of these columns, the diameter of which was $\frac{1}{333}$, three of the spaces between the lines which I measured were $\frac{1}{16000}$, $\frac{1}{10000}$, and $\frac{1}{4750}$ of an inch in width. When several of the prisms remained attached to each other, the lines on each of the adjoining columns were observed to correspond with each other, as if they were tessellated cells, not only in columnar arrangement as regards each separate prism, but they were also arranged layer above layer, in accordance with the natural planes of the shell; and this we shall presently find is not their true structure. Upon macerating portions of the recent *Pinna ingens*, in dilute hydrochloric acid, I obtained the animal matter of the shell in the form of a series of elongated cells, which retained their tubular character when in an undisturbed state, but which readily separated in planes parallel to those of the natural surfaces of the shell. Each of these layers presents such an appearance as a thin slice of the honey-comb of the bee would exhibit, if we were to take a section of it at right angles to the axes of the cells. If the maceration of the piece of shell in the weak solution of acid be arrested before the whole of the earthy matter has been dissolved, there is frequently a portion of carbonate of lime remaining within many of the cells, which illustrates, in a very striking manner, the nature of the structure and contents of these beautiful tissues. The cells have not uniform diameters, but some terminate with a point before they reach the outer or inner surfaces of the shell, while others extend through the whole intervening space. Neither is the number of angles constant, as in a circular space, $\frac{1}{50}$ inch diameter, I found they varied in this respect from three to nine.

If a fragment of the thinnest part of the shells of *Pinna ingens* or *saccata* be examined by transmitted light, in a little water between glasses, and with the inner surface towards the eye, the mode of arrangement of the cells will be displayed in a very satisfactory manner; and if the power applied be not less than 500 linear, a very beautiful reticulated system of vessels may be frequently observed occupying the angles formed by the terminations of the cells, at the natural surface of the shell, as represented at Pl. xiv. fig. 6, *a*. Sometimes a portion of the vascular structure is destroyed, as represented in the figure, and the disrupted ends of the vessels are frequently seen projecting partly across the areas of the network, but the courses of the tissues thus removed may be readily traced by a depressed line, which indicates the directions of their embedments. In other cases the vessels are not so readily to be seen, as there is frequently a rude gelatinous-looking network spread over the vascular structure, filling up

and obscuring the angular junctions of the cellular structure beneath, as represented at Pl. xiv. fig. 7, *b b*; but it is often the case that portions of this envelopment have been removed, and the vessels running beneath it are then readily to be seen, as at Pl. xiv. fig. 7, *a a*. Upon tracing these vessels amid the animal remains I obtained by maceration in dilute hydrochloric acid, I frequently found them disengaged from the angles, and floating freely and unconformably on the surface of the membrane. This disengagement evidently arose from a rupture of the vascular system, as upon a close examination I observed that the vessels apparent at the natural surfaces, are not the only ones of this description that exist in the shell, but, on the contrary, that there was a series of these vascular networks, embracing the elongated prismatic cells, and which, impressing the lines of their courses upon the surfaces, caused the striated appearance that I have before described as existing upon the prismatic cells of *Pinna affinis*. These layers of vascular tissue are connected with those above and below them by a short vessel which proceeds from each angle of the several meshes of the network, so that the whole forms a regular, connected, and beautiful series, layer above layer, of reticulated vascular structure. When torn asunder in the direction of the natural planes of the shell, the sides of the cells separate at the lines where they are embraced by the vessels, and the thin membranes may be seen connecting the layers of vessels in such a manner as to produce an appearance resembling sections of honeycomb, at right angles to the axes of the cells (Pl. xiv. fig. 8). I have been unable to detect any diaphragms in the long prismatic cells, at the points embraced by the vascular tissues, by which they might be assimilated in some degree with the tessellated cellular structure of *Unio* and *Mytilus*.

Haversian canals are frequently to be seen, especially immediately beneath the outer surface of the shell.

The disposition of the cells in the genus *Ostrea* is widely different from that in *Pinna*, and in the genera which I have before described; the whole shell consisting of alternating layers of fleshy membrane and cellular structure, which are produced in succession from the inner surface of the shell. The normal condition of these tissues is exceedingly like that of the young lip of *Helix aspersa*.

If we remove the innermost thin laminated portion of the extreme edge of the shell of a half-grown oyster, and examine it immersed in water by transmitted light, with a power of 700 linear, we frequently find the outer margin to consist of a pellucid cartilaginous structure,

in which we see embedded, without any apparent order, and at uncertain distances from each other, numerous incipient cytoblasts. As we continue our examination inwards, we find these in all the various stages of growth, until the partially developed cells are seen assuming an approximation towards an arrangement, although not yet in actual contact, and presenting the appearance represented by fig. 3, Pl. xvi. At the bases of many of the cells the cytoblasts are to be seen in their fullest state of development. At this period the axes of the cells appear to be at right angles to the plane of the membrane upon which they are seated, but as they are developed in succession layer after layer beneath each other, until the stratum is six, seven, or more cells deep, the outer ones assuming a diagonal direction, their apices pointing outwards and backwards, as represented in Pl. xvi. fig. 4. As the cells reach their fully developed state, their membranous structure becomes too thick to allow of a distinct view of the cytoblasts which are seated at their bases; but in the young and immature cells these organs are very distinctly to be seen, provided the observer focuses the bases and not the apices of the cells.

If the fragments of the laminæ intended for examination be torn off in such a manner as to carry with them portions of the inner surface of the shell, it frequently occurs that this membrane is seen to be beautifully studded with matured cytoblasts, but without cells having been developed. These organs in *Ostrea* are different from any which I have observed in other shells, in which we usually observe them to assume either a circular or an oval form, but in this shell their fully developed form appears to be that of a rhomboid, as represented attached to the cells in fig. 3, Pl. xvi. The membranous structure which separates each stratum of cells from those above and beneath it, is thick, semi-opaque, and has a fleshy appearance. It abounds in Haversian canals, which average $\frac{1}{9000}$ inch in diameter. Sometimes they pursue their courses through this tissue in nearly a straight line, for a considerable distance, without branching or anastomosing, while in other parts they are tortuous, frequently anastomose, and throw off numerous short branches, which have cœcoid terminations, as represented in fig. 5, Pl. xvi., with the cellular structure imperfectly visible beneath the yellow semi-opaque membrane. The best mode of obtaining a satisfactory view of these organs is by the maceration of parts of the shell in weak hydrochloric acid; and if the animal matter thus obtained be carefully separated into laminæ, the canals, and the thin, pellucid, membranous structure of the cells, may be readily and successfully examined in a fluid medium, by

transmitted light, with a linear power of 500. Under these circumstances the canals may often be seen emerging from between the sides of the cells, sometimes presenting an abrupt cœcoid termination, occasionally ending in a short bifurcation, or pursuing their courses among them, and occasionally assuming an approach towards a reticulated form. This resemblance to a truly reticulated structure may be distinguished from the interstitial vessels by the greater size of the tissue, and the incompleteness of the reticulations, which sometimes pass but a third or a half round a cell or cells, while at others the circuit is completed, and the branch either anastomoses with the first portion of itself, or abruptly passes downwards between the cells in such a position, as to render its termination or course exceedingly doubtful.

An interstitial vascular tissue exists in *Ostrea*, as well as in *Pinna*, but it is much more difficult of observation in the former than in the latter. In a small portion of the inner surface of the shell from near its junction with the thin laminated edge, I succeeded, with a power of 1000 linear, in seeing two distinct layers, the one beneath the other, but I could not discern any short connecting vessels at right angles to their planes, such as are so readily to be seen in the analogous vascular tissues of the *Pinnæ*. These vessels are larger but not so symmetrical in *Ostrea edulis* as in *Pinna*, and they are frequently distended at intervals by an accumulation of gelatinous-looking matter, as seen in figure 5, Pl. xiv. which represents a portion of the interstitial vascular system of the shell of the common edible oyster, separated by means of weak hydrochloric acid. The vessels which I have hitherto described are not the only ones which exist in the shells of molluscous and conchiferous animals, for there is scarcely a membranous film that can be separated from the animal remains obtained by the maceration of these bodies in a weak solution of hydrochloric acid, in which exceedingly fine ramifying vessels may not be observed, provided a sufficiently high power be used in their examination; but this is absolutely necessary to a successful investigation of their structures, which requires powers varying from 500 to 1000 linear to ensure distinct and satisfactory results. After the description of the tissues already named, it is scarcely necessary to say, that, as a matter of necessity, there must be a free vascular communication between the animals inhabiting both univalve and bivalve shells and their habitations, through the medium of their points of attachment: but this fact is exceedingly difficult of demonstration; and, although I have used my best endeavours to trace the vessels both from the animal to the shell, and from the shell to the animal, I have not yet

succeeded in detecting them in their passage from the one to the other body, although I have found, at the junctions of the adductor muscle with the shells, both in *Pinna* and *Ostrea*, a layer of most elaborate and complex minute vascular tissue, and amid this other vessels, few in number and much greater in size. These vessels were evidently not those which appertained only to the muscle itself, as they were found in no other part of it, but concentrated in a single complex stratum at this point.

The periostracum, in both univalves and bivalves, is as highly organized as the other parts of the shell; and in all the species which I have subjected to examination, it presents every symptom of possessing a high degree of vitality. If it be removed from the other structures by maceration in a weak solution of hydrochloric acid, immersed in water between glasses, and examined by transmitted light, with powers varying from 200 to 500 linear, it will be found, in *Mytilus*, *Oliva*, *Bulla*, *Cyclostoma*, *Cypræa*, and numerous other genera, to abound in minute ramifying vascular tissues, varying in abundance, and somewhat in character, in different genera. Sometimes they are seen (especially in the last-formed parts of the periostracum) in a progressive state of development, the larger trunks being apparently perfectly tubular in their structure, while the branching and terminating portions are more or less composed of irregular moniliform strings of gelatinous molecules, as if the vessels were in progress of development, in a similar manner to that which I have described as occurring in the formation and development of the minute vascular tissues of the Corallidæ, in the 'Philosophical Transactions,' part 2, 1842, page 220, pl. 17.

The periostracum possesses also in an eminent degree, both reproductive and reparative powers. In almost every instance that has fallen under my observation, it is found to abound in cytoblasts, varying in their characters in different genera and species. In the greater number of instances, they do not affect any particular mode of arrangement, but are developed in groups over the whole surface of the membranous structure wherever it needs strengthening. In some cases they are seen advancing as it were in broad bands over the surface of the organ, from the hinge towards the lip, in the manner exhibited in fig. 7, Pl. xvii. which represents a portion of the periostracum of *Solen vagina*, which was separated from the shell by maceration in dilute hydrochloric acid. In the front of the line of progression (*a*) they are observed in their earlier stages of development of cellular structure, but as we recede towards the line (*b*) the

tessellated cells are seen in their advanced stages of growth, closely packed together, and incorporated with the tissue beneath. One of the largest of the cells, with its accompanying cytoblast in the line of advance (*a*), measured $\frac{1}{1430}$ inch in diameter, while a smaller one, in which the cytoblast and its nucleus were equally distinct, did not exceed $\frac{1}{10000}$ inch.

Among the aquatic univalves there are some which have these organs in a much greater degree of perfection than others, and in none are they displayed in a more beautiful manner than in the periostracum of *Lymnea stagnalis*, one of the commonest of our fresh-water shells. If the periostracum be removed, in the manner before described, by the aid of dilute hydrochloric acid, and examined as a transparent object, with a linear power of 250, we find them in some parts irregularly dispersed over the surfaces, of an oval form, and usually exhibiting a distinct and very curious description of nucleus, as represented at fig. 1, Pl. xvii. In some of these oval bodies, the nucleus, beneath a power of 550 linear, appeared like a vesicle which had collapsed irregularly, as represented in fig. 6, Pl. xvii. while in others it assumed the appearance of a short, thick, convoluted thread, as represented in fig. 5. This curious form of the nucleus is different from any that I have observed in other shells. In other parts of the same periostracum the cells assumed quite a different form (that of an oblong), and were arranged end to end in short branching lines, as represented in fig. 2, Pl. xvii.; and when viewed with a power of 550 linear, many of them were found to contain numerous minute globular bodies, probably incipient cytoblasts, as seen in fig. 3, Pl. xvii. One of the largest of this description of cell (*a*, fig. 3) measured $\frac{1}{1430}$ inch in length by $\frac{1}{2857}$ in breadth. The whole of the periostracum of this shell, when in its adult state, appears to be covered by an exceedingly fine membrane, thickly studded with minute mamillated spots (*a*, fig. 2, Pl. xvii.). These spots certainly cannot be considered to be cytoblasts, from the regularity of their disposition, and from the universal absence of a nucleus, even when examined with a linear power of 1020, as represented by fig. 4, Pl. xvii. One of the largest in this group which I measured was $\frac{1}{14000}$ inch in diameter.

The periostracum of *Trigonia Lamarckii* furnishes another exceedingly curious variety of the development of membranous tissues through the agency of cytoblasts. In my observations "On the Organic Tissues in the Bony Structure of the Corallidæ," ('Philosophical Transactions,' part 2, 1842, p. 220, plate 17, figs. 3 and 4),

I have described these organs as generating from the surface of the membrane, not as a series of separate and perfect cells, but as long, sacculated projections, the apex of each being crowned by the cytoblast which originated it, by the projection of the membranous tissue from its circular edge, in a backward direction; and it is singular that we have in the periostracum of *Trigonia Lamarckii*, a series of sacculated tissues, which are strikingly analogous in the mode of their development to those which I have described as occurring in *Cellepora pumicosa*. If the periostracum of *Trigonia Lamarckii* be detached from the shell by the action of dilute hydrochloric acid, and examined in fluid between glasses, with the outer surface towards the eye, it presents the appearance of a beautiful network of broad yellow fibre, having the interstices filled with a convex membrane, on the centre of which there is a large circular cytoblast, as represented in fig. 3, and also in fig. 4, Pl. xv., as seen with a power of 1020 linear. If the inner surface of the membrane be presented to the eye instead of the outer one, the appearance of the tissue is considerably altered, and under these circumstances the structure resembles a series of short honey-comb cells, having the cytoblasts at their concave terminations. There is no membrane whatever at the bases of these sacculated projections, nor can any indication of one be discerned between that part and the inner surfaces of the cytoblasts, while on the outer convex surfaces, the membranes surrounding those organs, although exceedingly pellucid, are yet readily to be distinguished by frequent corrugations of their surfaces. The terminations of the sacs on the outer surfaces are frequently wholly or partially surrounded by a double line, as if in their advance beyond the plane of the reticulated tissue, they had carried with them, to a certain extent, a marginal fringe, composed of a portion of the thread of the network. No indications of vascular tissue were observed on the outer surface. The bases of the sacs, viewed with the inner surface of the periostracum towards the eye, have usually the appearance of being formed of a thin, rounded, marginal edge, which sometimes has much the aspect of vascular tissue, although I do not think, from all the appearances combined, that it is so. But if we obtain a view into the sac, in a diagonal direction, there is frequently the appearance of a vessel crossing its side at right angles to its axis, about half-way between its base and apex; and from having frequently observed this appearance upon the inner surfaces of the sacs, I am much inclined to believe that such a tissue exists in that situation.

From the close approximation of these sacs to each other, they are

angular by compression, but the number of angles is by no means certain, and they vary in this respect from three to seven or more.

The reparation of wounded and diseased shells is a part of our subject which is of high interest to the physiologist, and upon which much might be written, but I must on this occasion content myself with but slightly adverting to it.

In cases of fracture of the shell, the process of repair is exceedingly similar to the analogous operations in the bones of the higher classes of animals. An effusion of coagulable lymph takes place cytoblasts are produced; cellular structure quickly succeeds, in which the earthy basis of the shell is secreted, and the fractured parts are firmly cemented together.

If the accident be of less extent, such as an injury inflicted on the inner surface of the shell, the process is precisely that which I have described as taking place in the extension of the lip in the young shell of *Helix aspersa*. A new membrane is formed by the effusion of coagulable lymph; cytoblasts and cells are developed; and secretion of carbonate of lime commences at the edge of the membrane. As the processes of development and secretion proceed gradually inwards, the centre of the membrane is eventually reached by the encroaching circle, and the whole of the wounded surface is covered by a new stratum of cells and membranous tissue. Such precisely is the operation which has taken place on the inner surface of one of the shells of *Modiola papuana* which I have in my possession.

The mode of effecting repairs in the periostracum is in some respects different from the analogous operation in the shelly structure. One of the specimens of *Solen vagina* in my possession has had this organ pierced in a great number of places; and the examination of these wounds affords so many interesting phenomena, and exhibits evidence of the existence of so high a degree of vitality, as to render it necessary to enter somewhat at length into this part of our subject. In this case the wounded part is in such a position as to preclude the possibility of the animal exuding a layer of coagulable lymph so as to form a new basement membrane, in the manner in which the addition to the lip is effected in the univalve, or in the repair or extension of the inner surface of the bivalves. Nature has, therefore, had recourse to other means for the production of the basement membranes of the new tissues, which are required to be produced to supply the places of those which have been destroyed or displaced; and this is effected by the slow extension of the inner layer of the periostracum, which gradually encroaches from all sides on the

wounded area, until it meets in the centre and the denuded surface of the shell is covered. The new membrane is at first clear and pellucid, but, after a short period, minute vesicular molecules and cytoblasts appear; solitary spherical cells are next observed dispersed over the surface, especially towards the edge of the wound, and small patches of minute vascular tissue may be seen. As the process of reparation proceeds, the spherical cells increase in size, and assume the form of collapsed vesicles, frequently having a depressed line across their centre, on each side of which there is a partial inflation remaining. As they increase in number towards the edge of the wound, their outlines become more indistinct, until at last they form an even paving or thickening of closely-compressed tessellated cells, whose junction with each other is scarcely to be distinguished. Layer after layer of this tissue follows each other, tier above tier, until the space of the wound is completely filled up. But this portion of the process of reparation, is not effected with anything like the same degree of rapidity that marks the production of the basement membrane, which is frequently perfected, and completely covers the previously exposed surface of the shell, while the restoration of the remainder of the tissues has apparently progressed but very slightly, as shown in fig. 8, Pl. xvii. which represents a portion of one of the wounded spots, seen with a power of 300 linear. The minute vessels to which I have before alluded quickly make their appearance on the surface of the newly-formed basement membrane, and afford one of the most interesting studies of the origin of simple, branched, and anastomosing vascular tisues, that I have hitherto had the good fortune to meet with.

In the course of my investigation of the animal tissues of the bony skeletons of the true Corallidæ, I have described and figured the vascular tissue found in *Millepora alcicornis*, which is seen to consist of exceedingly minute vessels, simple in their character and frequently terminating abruptly, but having beyond the termination of the truly vascular portion a linear series of cytoblasts, as if the completion of the vessel had been arrested at the period of the death of the animal. In other parts of the same specimen, detached patches of straight and curved linear series of cytoblasts were of frequent occurrence.* In my examination of the animal tissues of *Cellepora pumicosa*, in the same paper,† I have described a series of large sacculated projections of membranous tissue, supported on the basement membrane of the coral, and crowned, each one, with a large and strikingly

* Phil. Trans. part 2, 1842, p. 220, pl. 17, fig. 2. † Id. p. 220, pl. 17, figs. 3, 4.

beautiful cytoblast, which, having been originally seated on the basement membrane, had projected a cylindrical tube of membranous structure from the under side of its margin, to such an extent as frequently to elevate it fifteen or twenty times the length of its own diameter, from the surface of the membrane upon which it originally reposed. These sacculated bodies are almost always furnished with extremely minute vessels, that occasionally give off short branches, which are sometimes observed to terminate in a linear series of three or four cytoblasts.

I have alluded to the description of these structures somewhat at length, as it will be seen that the vascular tissues on the new basement membrane of the wounded shell are intimately connected in their origin and structure with those of the Corallidæ, and that in conjunction with them they will afford interesting demonstrations of the mode of generation of the primary vascular tissues, not only in animals comparatively of a low degree of organization, but also, it is to be hoped, in those of the higher warm-blooded classes, as I have observed these primary vessels amid the cartilaginous fibres of a portion of the fœtal skull of an infant, which had been deprived of its carbonate of lime by maceration in dilute hydrochloric acid, and also in the somewhat similar cartilaginous structure in a case of *mollities osseum*, at St. Thomas's Hospital, described by Mr. Samuel Solly.

Let us now return to the basement membrane of the wounded shell. If, with a microscopic power of 500 linear, we examine this tissue in the earliest stages of its development, and before it has closed in the centre, there are usually but very slight traces of vascularity to be found. A few simple but very slightly branching vessels are to be seen dispersed, frequently at considerable distances from each other. In this stage of their existence they do not appear to be a part of one great plexus buried in the substance of the membrane, of which portions only are to be seen, but are truly separate centres of primary vascular structure; for if we use a high magnifying power, 1000 or 1500 linear, and focus the structures with great care, we may readily convince ourselves that they are not embedded in the substance of the basement membrane, but are produced upon its surface, and are but slightly adherent to it, for it frequently occurs that branches are seen projecting from its plane; and at the torn edges of the membranes also they are often seen extending considerably beyond the margin, and in this state are frequently terminated by a large and well-defined cytoblast.

If we examine these detached patches of young vascular tissue,

with a microscopical power of about 1000 linear, it will appear that they are rarely found to consist of a continuous and unbroken tube for any considerable distance, and we shall observe that they are formed of a series of moniliform parts of unequal length, the whole being constructed by the junction of a linear series of minute cytoblasts, in a similar manner to that which I have described as the mode of the production of similar minute vessels in the tissues of the Corallidæ. As the vessel approaches maturity, the divisions into moniliform parts become less frequent, until at last it assumes the appearance of a tube, filled, excepting at slight and irregular intervals, with a yellow gelatinous matter; and in the complete state the gelatinous line is nearly continuous and unbroken, as shown in the fragment represented at *c*, fig. 4, Pl. xviii.

The vessels are not always composed of a series of cytoblasts of equal diameters, nor at an equal distance from each other, but occasionally they are constructed of small cytoblasts disposed at irregular distances, along with which there are others of comparatively great size, with large and very distinct nuclei, as represented at *a a*, fig. 3, Pl. xviii. In this case, when closely adjoining, they at once unite; but if short intervening spaces exist between, each cytoblast generates its own portion of the tissue, which portions approximate and unite together, until the whole forms a series of continuous, irregular, moniliform vessels, as represented in fig. 3, Pl. xviii.; or it sometimes occurs that all the cytoblasts of the series are of the large-sized description, with the distinct nucleus, as represented by fig. 5, Pl. xviii. The production of branches is achieved by an extension of the same laws that govern the generation of the main trunks of the vessels. A single cytoblast is generated upon, or becomes attached to, the side of a vessel. Membranous structure is detached from its under side, in accordance with the laws that I have previously described, and a short cylinder of vascular structure is produced, bearing upon its summit the large spherical cytoblast from which it has emanated, and in proportion as this organ is endowed with productive power, so we have the branches either long or short. While in a state of vigorous action the cytoblast appears to retain its spherical form, original diameter, and distinctly nucleated appearance, as represented in *a*, fig. 4, Pl. xviii.; but as it declines in vigour it decreases in size, assumes an oval shape, and loses the nucleated appearance, (fig. 4, *b*); and this diminution of its diameter continues gradually to take place, until, at the period of the cessation of its productive power, it is reduced to the ordinary diameter of the vessel

it has generated, and finally forms a cœcoid termination to it. By the production of branches in this way from all parts of the originally small and widely separated centres of vascular tissue, the whole becomes ultimately united, and forms one large and intricate plexus; for it may be frequently observed in the young basement membrane, that while some of the groups of vessels are isolated, there are patches situated near each other, which, although each may have freely anastomosed with the members of its own group, yet they are connected with each other by one or two points of junction only, while, on the contrary, in the more advanced stage of the tissues, isolated vessels or centres of vascularity are rarely to be detected in the interstices of the general plexus.

The vascular tissue, which I have described above, is not peculiar to the new membrane of the wounded parts of the shell, but it exists, I believe, in the same relative situation on all parts of the basement membrane of the uninjured periostracum, as it may be frequently observed when that organ is sufficiently thin and transparent to permit of distinct vision with high microscopical powers, and especially in the young portions near the edge of the shell.

I have not had the opportunity of examining either human false membrane in a sufficiently early state of development, or human fœtal tissues, to be enabled to say that the production of vascular tissue in our own species is in accordance with the facts which I have just described; but I have little doubt that ultimately such will prove to be their origin, for Bowman has noticed corpuscles in the coats of capillary blood-vessels, in the sheath of nerve, and in the substance of tendon, but believes them to be "the nuclei of cells, from which these several structures have been originally developed."

The arrangement of the cytoblasts in linear series is probably due to an electrical or polar action among themselves, each molecule appearing to have a distinct axis that determines the position in which one approaches the other. Thus in the compressed discoid cytoblasts of the animal membranes of the coral, *Millepora alcicornis*, the polar axis appears to pass from certain points in the circumference, through the centre of the body, midway between the two broad surfaces; thus inducing an arrangement of the disks edge to edge: while in the disks of the human blood, the polar axis appears to pass from centre to centre of each of the broad disks of the corpuscles, or in a direction exactly the reverse of the cytoblasts of the coral: thus inducing a linear arrangement of the blood-disks, with their broadest surfaces in contact, or after the manner in which a pile of coin is packed, and which

mode of disposition is so familiar to every observer of the blood by means of the microscope.

It is difficult to divine to what extent this law may obtain under other circumstances, but we have every indication of its operating extensively in numerous cases of the origin and increase of newly-formed animal tissues in the *Corallidæ* and the *Spongiadæ*, as well as in the beautiful and highly organized subjects of the present paper, in the membranes of which we have seen it exerted in the mutual attraction and arrangement of the cytoblasts for the production of the new vascular tissues of the periostracum and other tissues of the shell. The same law also appears to be called into action in the production of the muscles of animals; for Bowman, in his paper on muscular fibre, published in the 'Philosophical Transactions' for 1841, says at p. 484: "It is now well known through the researches of Valentin and Schwan, that the fasciculi of voluntary muscle in the earliest stage of their development, consists of a series of nucleated cells, and that the nuclei continue visible during the period of fœtal growth."

There is another phenomenon which accompanies the restoration of the wounded parts of the periostracum of the shell, which is exceedingly interesting, as it appears to be the result of a natural effort in aid of the reproductive process, very nearly allied to that which is attained by Nature in the healthy marginal inflammation of the wounded parts in the fleshy tissues of the warm-blooded animals.

If we examine the outer margin of the wounded spot in the periostracum, with a power of 200 or 300 linear, we always observe that it presents a finely-fringed appearance, like dendritical filaments, springing from the extreme margin of the healthy periostracum, and penetrating its substance to a small extent, as represented at Pl. xvii. fig. 8. If we examine this object with a power of about 1000 linear, we find that this appearance is caused by the healthy periostracum immediately surrounding the wound being excavated into an infinite number of short bifurcating canals, of nearly equal diameters, as represented at *a a*, fig. 1, Pl. xviii. There is to all appearance but one thin stratum of these curious organs, and this by measure is $\frac{1}{1000}$ inch, beneath the outer surface of the periostracum. I have been unable to detect them in the space between this layer and the basement membrane. In some cases they extend much further beyond the dark margin of the new tissues than is represented in fig. 1, Pl. xviii.; and in one instance I found a circular patch of them radiating from a small dark dot near the centre of the patch, as if the reparative process had been completed, and they alone remained as an evidence of

the former existence of a wound. It is difficult to divine the precise office which they fulfil in the restoration of the wounded tissues, but that they are connected with this process is evident from their being frequently to be found amid the newly-formed layers of tessellated cells, which are seen tier above tier, advancing from the healthy margin towards the centre of the wound; and, under favorable circumstances, their communications may be traced with those permeating the old periostracum.

There are other tissues in bivalve shells, which, like the structure of the periostracum just described, evince a much higher degree of organization than naturalists have hitherto believed to exist in shells of molluscous or conchiferous animals. Thus, in the inner surface of many bivalves, there are tissues which very closely approach in their structure to the areolar tissue, described by Mr. Bowman in his treatise on mucous membrane, in the 'Cyclopædia of Anatomy and Physiology.'* In many shells the tissues, which I believe to be analogous to those described by Mr. Bowman, are of extreme tenuity, while in others they are much more easily to be observed; but in none which I have examined are they developed in a greater degree of perfection than in *Venus decussata*, and to this therefore I shall limit my description. If the shell be macerated in very dilute hydrochloric acid until it is entirely deprived of its calcareous matter, and then examined in water, with the inner surface towards the eye, with a power of 160 linear, we shall observe, immediately beneath the membrane lining the interior of the shell, three or four layers of a

* The author, in describing the areolar tissue, says, "It in truth consists of two tissues, distinct from each other, and respectively allied to the white and to the yellow fibrous tissues. The white fibrous element of areolar tissue is chiefly in the form of bands of very unequal thickness, in which are to be seen numerous streaks taking the general direction of the whole, but not parallel to the border, nor continuous from end to end. These streaks more resemble the creases of a longitudinal folding than intervals between the separate fibrillæ, for which they have been mistaken. These bands split up without difficulty in the long direction, whence result fibrils of the most varied width, the finest being far too minute for measurement, even with the best instruments. These bands interlace and cross one another in various directions, and their natural course is wavy. They frequently subdivide and join those near them. Besides these bands, commonly called fasciculi, there are some finer filaments of the utmost tenuity, which seem to take an uncertain course among the rest. The yellow fibrous element is everywhere in the form of solitary fibrillæ, which correspond in their essential characters with the tissue of that name. They are disposed to curl, and are truly branched at intervals of variable length; these branches (which usually retain the size of the fibril from which they spring) becoming continuous with others in the neighbourhood."

yellow fasciated tissue, forming numerous oval and round areas, of very unequal size, and disposed without order or reference to the open areas of the neighbouring layers, either above or below. When the fasciæ are wide, they appear membranous and unevenly plicated within the margins, which are usually rounded or thickened; but when they are narrow they assume a swollen and ligamentous appearance, as represented in Pl. xviii. fig. 7.

At the base of this tissue there is a thin membrane of an even texture, which presents a finely granulated surface when viewed with a power of 600 linear. Immediately beneath this is seated the tissue, which appears to me to be equivalent to the "white fibrous element of areolar tissue" of Bowman. With a linear power of 250 it has the appearance represented in Pl. xviii. fig. 8. With this power it seems as if the striations were produced by a series of parallel contractions, of an upper and softer stratum of the membrane, as the lines of division are not continuous, but frequently merge into each other, and the edges of the supposed fibres appear ragged and unconformable; but upon examining it with a microscopic power of 1020 linear, the object presented a widely different aspect, and the striations now appear as if they were produced by lines, composed of parallel fasciculi of minute tortuous vessels, buried in the substance of a comparatively thick membrane; but I am induced to believe that this is not in reality the structure of the tissue, but that the fasciculated appearance of the vessels is due to the tissue being composed of numerous thin layers of basement membrane, each having a series of single vessels running parallel to each other, and that the lines of vessels are conformable with each other in the whole of the membranes of which the tissue is composed; for in several parts of the preparation I am describing, there are fragments of exceedingly thin membranes, which project from the torn edges of the fibrous tissue, and which are furnished with parallel lines of single vessels. The courses of these vessels through the tissue are not in undeviating lines, but slightly undulating, so that a series of them would naturally give the confused and tortuous appearance which exists in the membrane, in its natural and undisturbed condition.

It would appear from Mr. Bowman's description, which I have already quoted, that he saw similar minute vessels in the corresponding tissue of the mucous membrane of the human subject, for he says,—"Beside these bands, commonly called fasciculi, there are some finer filaments of the utmost tenuity, which seem to take an uncertain course among the rest." When the shell-tissue is torn at right angles

to the courses of these vessels, they are seen projecting in great numbers from the fractured edge; and their vascularity may be readily demonstrated with a power of 1020 linear, as they frequently contain portions of an amber-coloured gelatinous matter, which induces a slight increase in their diameters at those parts. One of the vessels under these circumstances measured $\frac{1}{21276}$ inch in diameter.

In concluding the detail of my researches, I may be allowed to observe, that I have no doubt that many other interesting and beautiful tissues will be found by future investigators of these highly organized and elaborately constructed bodies, for I can assure my readers that I have by no means exhausted the subject, but on the contrary, have rather confined myself to pointing out the general laws displayed in the organization of univalve and bivalve shells, than entered into a detailed description of the numerous beautiful tissues that have passed beneath my eye during the course of this series of observations; and the scientific conchologist, I am convinced, will find in the investigation of the organic tissues of shells, powerful assistance towards a natural arrangement of genera, and a most efficient aid in determining doubtful species.

EXPLANATION OF PLATE XIV.

Fig. 1. A portion of the new membranous lip of *Helix aspersa*, in its natural state, with cytoblasts and cells in progress of development.

a, *a*, *a*. Vascular tissue in progress of formation.

Fig. 2. A portion of the lip of the same shell.

a, *a*, *a*. Vascular tissue in its early stage of development.

Fig. 3. Detached cells and cytoblasts in various stages of development, from the young lip of *Helix aspersa*.

Fig. 4. Linear arrangement of nucleated cells, illustrating the early stage of the development of prismatic cellular tissue, in the young lip of *Helix aspersa*.

Fig. 5. Interstitial vascular tissue of *Ostrea edulis*, separated by maceration in dilute hydrochloric acid.

Fig. 6. Interstitial vessels running in the angles of the terminations of the cells at the inner surface of *Pinna*.

a, *a*. The vessels *in situ*.

b, *b*. The impression left by the vessels after they have been removed.

Fig. 7. Interstitial vessels similar to those represented in fig. 6, but partially hidden by the gelatinous looking covering.

a, *a*. The vessels exhibited by the absence of the covering.

b, *b*. Portions of the preparation where the vessels are concealed by the covering.

Fig. 8. Section of prismatic cells of *Pinna ingens*, at right angles to their axes, showing the layers of vessels connected by the membranous tissue of the sides of the cells.

EXPLANATION OF PLATE XV.

Fig 1. *Cypræa Mauritiana* fractured at right angles to the lines of growth.

a, *a*. Part of the central stratum of plates of prismatic cellular structure, crossing each other at right angles.

b. The outer stratum of plates of prismatic cellular structure, exhibiting the basaltiform columnar appearance arising from the section being at right angles to the planes of the plates.

Fig. 2. Prismatic cellular structure of the thin stratum from the interior of a *Conus*, showing the mode in which the cells frequently divide or unite with each other.

Fig. 3. Upper surface of periostracum of *Trigonia Lamarckii*, with its cytoblasts.

Fig. 4. One of the cytoblasts magnified 1020 linear.

EXPLANATION OF PLATE XVI.

Fig. 1. Cellular structure of *Haliotis rubra*.

a, *a*, *a*, *a*. Sections of Haversian canals.

Fig. 2. A portion of a plate of fan-shaped prismatic cellular tissue from a bivalved shell from the gault formation.

a, *a*, *a*, *a*. Longitudinal Haversian canals.

b, *b*, *b*, *b*. Transverse Haversian canals.

Fig. 3. Young cellular tissue of the shell of *Ostrea edulis*, with cytoblasts.
Fig. 4. Adult cellular tissue of *Ostrea edulis*.
Fig. 5. Haversian canals in the membranous tissue of the shell of *Ostrea edulis*.

EXPLANATION OF PLATE XVII.

Fig. 1. A portion of the periostracum of *Lymnea stagnalis*, with oval cytoblasts.
Fig. 2. Periostracum of the same shell, exhibiting the linear arrangement of oblong cells, and the mamillated outer membrane at *a*.
Fig. 3. Some of the oblong cells represented in fig. 2, magnified 550 linear, to show the minute globular bodies that they contain.
Fig. 4. A portion of the mamillated outer membrane of the same shell, seen with a power of 1020 linear.
Fig. 5. and 6. Two of the oval nucleated cytoblasts represented in fig. 1, seen with a power of 550 linear.
Fig. 7. A portion of the periostracum of *Solen vagina*, exhibiting one of the broad bands of cells and cytoblasts upon its surface.
a. The front of the band. *b*. The back.
Fig. 8. Part of one of the wounded spots in the periostracum of *Solen vagina*.
a. New basement membrane, with primitive vascular tissue.
b. New layers of cellular tissue, advancing from the circumference towards the centre of the wound.

EXPLANATION OF PLATE XVIII.

Fig. 1. Represents a small portion of the edge of one of the wounded spots in the periostracum of *Solen vagina*, with a power of 1020 linear.
a, *a*. Bifurcating canals excavated in the healthy periostracum surrounding the wounded part.
b, *b*. New cellular structure within the margin of the wound.
Fig. 2. Primitive vascular tissue of the new basement membrane of the wounded periostracum of *Solen vagina*, in nearly a complete state of development, terminating at one end with large nucleated cytoblasts.
Fig. 3. A small plexus of primitive vascular tissue, in an early stage of formation.
a, *a*, *a*, *a*, *a*, *a*. Large nucleated cytoblasts intermixed with the smaller ones of which the tissue is principally composed.
Fig. 4. Primitive vascular tissue of the new basement membrane completely developed.
a. A nucleated cytoblast in active condition, terminating a branch in course of development from its under surface.
b. A young branch terminated by a nearly exhausted cytoblast.
c. Part of the vessel filled with the yellow gelatinous substance.
Fig. 5. Linear arrangement of large nucleated cytoblasts in the earliest stage of the development of vascular tissue.
Fig. 6. Primitive vascular tissue, with branches in different stages of development.
Fig. 7. Yellow fasciated tissue of the inner surface of *Venus decussata*.
Fig. 8. White fibrous tissue of *Venus decussata*.

XX. — *Remarks on a peculiar form of Spiral Vessel.*

By Arthur Hill Hassall, Esq.

Read Nov. 16, 1842.

While recently engaged in examining the decayed gourd of the vegetable marrow, with the view of finding the *Fungi* which are so influential in producing the destruction of fruits, my attention was directed to a peculiar modification of spiral vessel. On placing a bundle of the spiral vessels of the gourd of this plant beneath the microscope, each vessel is plainly seen to be striated by a number of longitudinal lines, which might, at first sight, be regarded as plaits in the enclosing membrane of the *spiral* fibres, but are really secondary *fibrillæ;* as may be proved,—first, by the circumstance that they are distinctly separable from this membrane, and secondly, by the fact, that if a spiral vessel be broken up, and the fibre uncoiled, the longitudinal *striæ* will be observed to have separated into numerous short pieces, which adhere to each turn of the spiral fibre; and again, that if an interior view of a vessel be obtained, the extremities of the *striæ* may be plainly seen interrupting its circularity. These longitudinal *fibrillæ* are very numerous, varying in number from six or eight in the smaller vessels, to as many as twenty in the larger (see Pl. xix. fig. 1, 2, 3). They are very much smaller than the spiral fibres, to the internal surface of which they are attached; and the only office which can apparently be assigned to them, is that of strengthening the walls of the tubes, and preventing, by their adherence, the too great protrusion of the investing membrane of the vessel.

On describing this form of vessel, which I had imagined to have been unobserved, to Mr. E. J. Quekett, that gentleman informed me that he had himself noticed it, and supplied me with the following information respecting it: "The first figure of a vessel with longitudinal *striæ* which I have seen, was in 'Schultz's Memoir on the Circulation of the Ducts of the Latex,' from *Urania speciosa*, though I had previously seen it in *Loasa contorta*, in the *petiole*. It has been observed since by Mr. W. Wilson, in *Typha latifolia*, and I have recently found it in *Canna bicolor*."

It would therefore appear, that this form of spiral vessel is by no means rare, but still the recorded instances of its occurrence are not so numerous as to render a further enumeration of plants in which it may be found, destitute of interest.

EXPLANATION OF PART OF PLATE XIX.

Fig. 1. A magnified portion of the spiral vessel of the Vegetable Marrow.
Fig. 2 and 3. The same unrolled.

XXI.—*On the Nature of Vessels possessing Longitudinal as well as Spiral Fibres, found in certain Plants.* By EDWIN J. QUEKETT, Esq., F.L.S., &c.

Read May 17, 1843.

HAVING given to the Society at some of its earlier meetings a few observations on the structure and development of the vascular tissue of plants, and as this subject still continues to occupy my attention, I intend this evening to offer to your notice some remarks connected with vessels, which present an evident longitudinal, as well as a spiral, arrangement of fibres in their interior.

These vessels are not present in the majority of plants, and have not, until within the last few years, been described; but since they have been detected, observers have found them in very different orders of plants, and it is not improbable that future investigators may succeed in discovering them in a still greater number of plants than those in which they have hitherto been observed.

Schultz, in his 'Memoir on the Circulation in the Ducts of the Latex,' figures a vessel of this kind found by him in *Urania speciosa.* Previous to seeing this figure, I had found a vessel of the same structure in the petiole of the leaf of a *Loasa.* Mr. W. Wilson, of Warrington, pointed them out to me in *Typha latifolia;* subsequently, I have met with them in *Canna bicolor.* Mr. Hassall has informed the Society this season, that he had met with similar vessels in a plant belonging to the *Cucurbitaceæ;* and I have lately detected something analogous in the footstalks of the leaves of the garden rhubarb.

The fact of finding vessels possessing a similar nature in classes and orders of plants differing in many points in their structure, offers the expectation, that hereafter they will be frequently detected in the vascular system of a variety of plants, especially of those that exhibit dots on the vessels arranged in some regular order.

The usual characters that these vessels exhibit, are the following:—In *Exogens* they do not appear to have either the length or diameter of those found in *Endogens,* where they certainly constitute the largest and longest of the vessels.

In *Loasa aurantiaca* they do not exceed the $\frac{1}{500}$th of an inch, whereas in *Urania* and *Canna* they are nearly the $\frac{1}{100}$th.

In their structure, they resemble ordinary spiral vessels in several points; having, more frequently than otherwise, two or more fibres, forming the same screw, coiled in the interior of the vessel, as in compound spiral vessels: — a "double-threaded" screw having been found in the gourd by Mr. Hassall, a four-threaded one in *Urania*, and an eight-threaded one in *Canna bicolor*.

In addition to this spiral arrangement, there are longitudinal deposits of fibres, the number of which varies considerably; some vessels not possessing more than six or eight, whilst in the larger, more than double the number can be detected. When force is applied to these vessels, they are reduced to a spiral ribbon, and the longitudinal fibres break at the same point as the membrane, the broken edges of the latter projecting beyond the edge of the spiral: (Pl. xix. fig. 4). The termination is very pointed, and one vessel overlies the other for some considerable space.

Such is the ordinary structure of these vessels: and I was induced to believe them to be perfect of their kind, and that they presented higher marks of development than the true spiral vessels; but subsequent observations have led me to conclude, that this longitudinal deposit of the elements of fibre is only a state preparatory to the complete developement of a vessel, exhibiting oval or quadrangular dots on its *parietes*. In examining the vessels as they occur in bundles, in *Canna bicolor*, where *annular* and *spiral* vessels (simple and compound) are to be found, it can be observed that all these manifest a tendency to produce longitudinal fibres, but it is only in the compound spiral, that the ultimate conversion of at first a spiral into a vessel with dots, regularly arranged in longitudinal rows, occurs. It is known, from the investigations of Mohl and Schleiden, that the spiral is the type of every other form of vessel; and vessels, whatever phases they ultimately assume, are, in early life, developed on the spiral plan; (perhaps an exception occurs in the vessels of woody exogens). The *annular* can be shown to be formed from a spiral, by two or more turns of the fibre, adhering in various parts of the membranous cylinder in which it is contained; and ultimately, the connecting portion of the fibre becoming absorbed.

It can be observed in the *reticulated* vessel, that the fibres, originally spiral, can be so connected by longitudinal, or longitudinally oblique processes of fibres, as to leave between them portions of the membranous cylinder, constituting what is known as a "dot;" these dots occurring in no regular order.

If this principle of the formation of dots be carried farther, it is not

difficult to conceive, that if a vessel, composed of many spiral fibres, which are a little remote from each other, have the several turns of the fibres connected by longitudinal ones, it will present a surface composed, like a net, of quadrangular meshes; this is, in fact, the case. The vessels, whose structure has been detailed, are in progress towards the dotted condition; some, undoubtedly, from the growth or elements of nutrition being suspended, proceed no farther than the state in which they have been described, but others arrive at their perfect development, the angles of the meshes being rounded, and the dot becoming more or less oval; they then appear to be dotted vessels of a certain kind. In some instances the various steps of the progress can be witnessed in the same vessel in *Canna bicolor*.

In examining vessels of this plant, it is very apparent that the deposition of the longitudinal fibre, from the early contents of the vessel, is a process far subsequent to the formation of the spiral fibre, as many vessels will afford the opportunity of seeing the latter perfectly formed, and the former absent, or only commencing to be formed, at one or the other extremity.

These vessels point out to us some of the means by which Nature, having first established laws, can, with the simplest elements, afterwards effect complicated changes, still maintaining the same unity of design in one plant, or portion of a plant, as in another.

When other kinds of *dotted vessels*, such as occur in woody exogens, are the subjects of examination, it will be found that the dots on such are of a still more complex nature, and which, by the investigations of the indefatigable Mohl, have been clearly elucidated. In all vessels of this kind the dots possess a central smaller dot, which appearance is chiefly due to a small depression occurring between two adjoining vessels, and projecting from without inwards in each vessel at the same spots, and to a deposit of "sclerogen," or fibrous matter in the interior of the vessel, which is thicker in every part than on the summit of the projections; in this way presenting to the eye a disk, with a centre of green or reddish colour, arising from the tenuity of the membrane decomposing the light in its transit through such a minute space.

XXII. — *On an instance of Monstrosity in a Moss.*

By Edwin J. Quekett, Esq., F.L.S., &c.

Read October 18, 1843.

It is well known at the present time that the several organs that constitute the flower and fruit of a plant, are but modifications of leaves; that is, that these organs are impressed, at their earliest formation, with a different law in their development, becoming subservient to the functions of reproduction instead of nutrition, the elements being the same in both cases.

The organs of the flower, consequently, are considered in a state of advancement, and that it requires some different power of the plant to form the parts of the flower out of leaves, than is required to form the ordinary leaves for nutrition. In any case, the floral organs are considered to be removed from leaves in an ascending order, and the highest pitch of development being concentrated in the formation of the petals, not only in converting the green calyx into coloured organs, but bringing back the stamens and carpellary leaves to petals, or to that condition which apparently they had gone beyond.

The metamorphosis of the normal condition of the organs of a flower, is familiar to most persons in what is termed "a double flower," in which there appears to be nothing but a mass of petals, the other organs being employed in the formation of the monstrosity.

The metamorphosis of flowers appears to be of two kinds, *centripetal* and *centrifugal:* that is, the organs from without inwards and from within outwards, take the character of petals, the petals being the imaginary organic centre, which does not alter its nature.

Instances of both these kinds of metamorphosis are frequent among cultivated flowers; of the former may be mentioned the *Polyanthus*, where the calyx assumes the character of the corolla; and of the latter the double stock, double cherry, double *Lychnis dioica*, and multitudes of other instances: in these, the several more internal organs, as the stamens and pistils, become converted to the nature of petals. The point I wish most to insist upon in the latter form of metamorphosis, is, that the carpellary leaves, which are employed in the formation of the pistil (seed-vessel), are not always converted into petals, but assume the green hue common to ordinary leaves. These, however, by the processes of horticulture, but chiefly by richer soils, can

be further changed towards the true character of petals; but the first change of the component parts of the pistil into leaves, implies that this organ is constructed of the same elements which, in some other portions of the plant, are devoted to other purposes; and the fact of their changing first into leaves, leads to the inference that the pistil, in its younger state, is more or less employed in connexion with the purposes of nutrition as well as of reproduction.

Instances of such kinds of metamorphosis as that just alluded to, are very common in "flowering plants," but such deviations from the normal state are more rarely witnessed among the "flowerless plants." Still, it can be observed, that the beautiful law of causing leaves under different states of modification to constitute the organs concerned in the perpetuation of the species, as well as in the assimilation of nourishment, obtains even in some of the higher orders of flowerless plants.

In certain ferns it may occasionally be seen that a group of minute leaves occupies the position of the part appropriated to the minute organs of reproduction (*sorus*), clearly demonstrating that the capsules which are replaced by leaves, must have a common origin with them: and Professor Lindley, in the 2nd edition of his 'Introduction to the Natural System of Botany,' p. 398, compares the *annulus* of the capsule of a fern to the midrib of a leaf; the *membranous case* of the sporules to the blade, and the *peduncle* to the petiole.

Since occurrences of this kind have been witnessed in the ferns, which departure from the ordinary character of these organs has enabled us to understand their structure, Professor Lindley has suggested the idea that the structure of the fruit of mosses may be conformable to the same law, after the following manner. "The *calyptra* may be understood to be a convolute leaf; the *operculum* another; the *peristomium* one or more whorls of minute flat leaves; and the *theca* itself to be the excavated distended apex of the stalk, the cellular substance of which separates in the form of sporules."— Introd. Nat. Syst. 2nd ed. p. 408.

It does not appear that specimens had been discovered by which the identity of the origin of the several parts of the fructification of a moss with true leaves could be demonstrated, and thus confirm the above supposition: I have however lately examined some specimens, which go far to prove that these minute organs are capable of being converted into leaves, leaving but little doubt that modifications of leaves are here employed, as in ferns and the higher orders of plants, to constitute the parts concerned in the duty of reproduction.

Soon after Mr. Ward had made known his plan of growing ferns and other plants in closely glazed cases, a plan admirably adapted also for physiological experiments, I had constructed a small case for the purpose of endeavouring to grow the mosses in the metropolis, in which were placed various species, both in fruit, and having the tendency to form fruit; the case being kept in doors, close to a window which faced the south.

Among the number so planted, was a mass of *Tortula fallax*, showing, at the time, the early condition of the *seta*, capped with a *calyptra*.

After watching the progress of the plants in the experimental case, it was discovered that the *Tortula*, which, when placed in it, showed every tendency to produce fruit, now presented a miniature forest of elevated stems, leafy above and below, but in the intermediate portion, destitute of leaves, instead of fruit advancing to maturation; in fact, all appearance of capsules approaching maturation was entirely dissipated.

On placing some of the plants under the microscope, it was evident that the specimens were furnished with the usual leaves at the base of the plant,—the *seta* existed, and presented the usual brown colour, quite destitute of leaves, but in the place of the capsule, there was a continued elongation of the *seta*, of a green colour, bearing several green leaves, varying in number in different specimens, being generally from about twelve to twenty; no doubt there would have been more, had the plants been allowed to continue growing. (See Pl. xix. fig. 5).

In this condition the specimens were now removed from the case, and dried for the *herbarium*.

From the view displayed by the microscope, it appears that the capsule had scarcely commenced to be formed, when the elements of the modified leaves, (which I conceive would have otherwise formed the capsule and peristome), having received an increased degree of heat, combined with more moisture than is natural to these plants, occasioned by the structure of the case, and by its position, instead of being converted into the ordinary capsule and peristome, the matters which entered the plants were appropriated, not in favouring the development of the organs of reproduction, but in effecting a change which carried them into a state fitting them apparently for the purposes of nutrition.

This change appears to have been accomplished by the *columella* continuing to elongate, and the leaves, whose apices, which it is con-

ceived would have otherwise formed the peristome, being carried up from their usual position, simply in consequence of the elongation of this organ.

It might be thought that the number of leaves on the axis ought to be the same, and not less than those constituting the peristome. But when the thirty-two leaves, which ought to have preserved the same plane, in order to form the peristome, are changed to an entirely different purpose, and become arranged on an axis which may elongate indefinitely, which elongation was suddenly arrested by taking the moss from the case, the specimens cannot offer anything decided on this point. This variation from the ordinary structure of the reproductive apparatus of a moss, fully bears out the views of Professor Lindley, on certain points, viz., those which relate to the *calyptra*, *operculum* and *peristome;* but it is not clear to me that the *theca* is the hollowed out apex of the stem. In the first part of this paper it was mentioned, that in certain monstrosities, such as the conversion of the carpellary leaves into petals, that the first act of destroying the seed-vessel, as in *Lychnis dioica*, and the "double cherry," was frequently to occupy its site by certain greenish leaves, not then petaloid; here we find an analogue to that which happens in mosses. The ripened capsule of a *Lychnis* is not unlike that of a moss, being urn-shaped, possessed of a certain number of teeth at the mouth, and having a central placenta, the representative of a *columella* within.

This organ can be entirely transformed into leaves, no one, in this plant, supposing it to be the hollowed out apex of the stem; therefore I am inclined to believe that if carpellary leaves are employed to form the peristome of mosses, of which there can be scarcely a doubt, that it is their apices which constitute this portion, and that others, by their united edges, form the *theca*.

When the floral organs of the higher order of plants are examined, an *involucrum*, *calyx* and *corolla*, besides the sexual organs, are occasionally found in the same flower; others more commonly possess *calyx* and *corolla only*, but many only a *calyx*. When we examine the fructification of mosses, it is found that the most simple have no peristome, that others have a single peristome, and that certain others have a double peristome. From the delicate dissections of these parts, by Valentine and others, it is shown that the peristome is connected with a membrane lining the *theca*, and does not spring immediately from its margin, showing that there are two organs, one within the other. This fact makes me consider the *theca* and *operculum* to be the representatives of a consolidated *calyx*, and that the *corolla* is the lining

membrane, whose fringed edge constitutes a peristome, which is either single or double, and appears to be the representative of the reproductive apparatus; and the columella is the receptacle, torus or axis on which these several organs are arranged. The *calyptra* being the analogue of the *bractea* or *involucrum*.

This view is apparently more conformable to the presence of *stomata* on the *theca*, which have been noticed by Treviranus, Bruch and Schimper, and Valentine, because if the latter organ be really composed of leaves, we may therefore, I imagine, more reasonably account for their existence there than by supposing it to be the excavated apex of the stem, such as occurs in an *Escholtzia*, for the *seta* is not an organ likely to be furnished with such pores.

The facts which have been stated, which I believe have not been before described as occurring in a moss, are some of those which, by a little interruption to the ordinary plan of Nature, allow us better to understand some of those plain yet perfect principles of operation, which become more and more evident to us, as we examine the subjects of Natural History.

EXPLANATION OF PART OF PLATE XIX.

Fig. 5. Plant of *Tortula fallax*, in its altered condition, showing the elongated seta bearing minute green leaves.

Fig. 6. Plant of the same in its natural state.

XXIII. — *On a Lever Movement to the Stage of the Microscope.* By ALFRED WHITE, Esq., F.R.S., &c.

Read November 15, 1843.

THE lever movement to the stage of the microscope having been very recently under the consideration of the Society, I am induced to lay before you a description of the plan I have used during the last three years, and find it much more convenient than the rack and pinion, or the screw.

It does not at all depend upon a particular construction of the guides to the stage, but only to the motion of its upper plate, or the one upon which the object to be viewed is placed; therefore to a stage with three, or to one with two plates, this plan is equally applicable.

It consists of a lever D, E (Plate xx.), to the shorter arm of which the ball B is firmly screwed, and moves in a socket formed by the upper plate of the stage A, and the cap C, which is a brass plate secured by two screws. This lever passes through the perforated ball, F, which moves in a socket formed by the arm G, which is attached to some immoveable part of the microscope, and the cap H, formed and secured as C.

The lever I have used is about 5 inches long, and has its longer arm E = 3, and the shorter, D, = 1, when in the position represented in fig. 1, (Plate xx.). But this proportion, when in use, is not constant, as will be seen by fig. 2; for the longer arm of the lever having been elevated and the shorter one depressed, and the ball B having travelled in a straight line to *b*, instead of a portion of a circle, it will be found that the shorter arm has increased by a quantity equal to the space between 1*f* and 2*f*, and for this reason the ball F is perforated to enable that part of the lever to move easily, though without shake.

As the end of the lever to which the hand is applied moves in all cases in an opposite direction to the ball B; and as the compound microscope inverts the image of the object viewed; it follows that the object will appear to move in the direction of the hand: and as for each position of the ball B, there is but one in which the other end of the lever can be placed, if a certain portion of the object is seen at any time, and it is required to bring the same part into the field again, this will be done by placing the hand in the original position.

I have stated before that this movement is applicable to any construction of stage-guides; I will now say a few words respecting its application to the stage with dove-tail slides having plates moving vertically and horizontally.

If applied to this kind of stage, it is as well to have the upper plate move vertically, for in that case the longer arm of the lever and its knob have to balance that plate only. But should the middle or second plate move vertically, then the lever must be sufficiently heavy to support the two plates when the stage is in the position represented in fig. 1.

Fig. 3 represents this mode of movement applied to a three-plate stage.

END OF VOL I.

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CORRIGENDA.

Page 7, line 2 note, for "*most*" read *least*, for "*least*" read *most*.
„ 11, line 1 note, for "*water*" read *turpentine*.
„ 11, line 3 note, for "*spiral*" read *chain-like*.

d. *Fig. 1* *c*

Fig. 2. *b.*

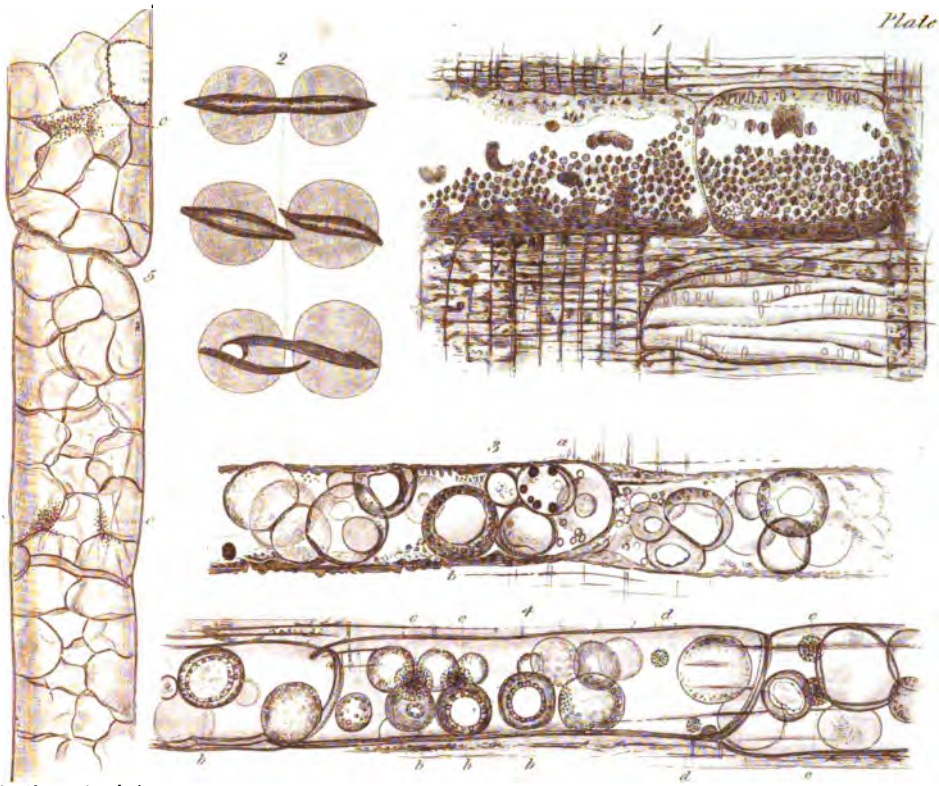
a.

Fig. 3.

From Hanson's Chiropteri Illustrated.

Lithographed by H. Bowman, London.

Plate 2.



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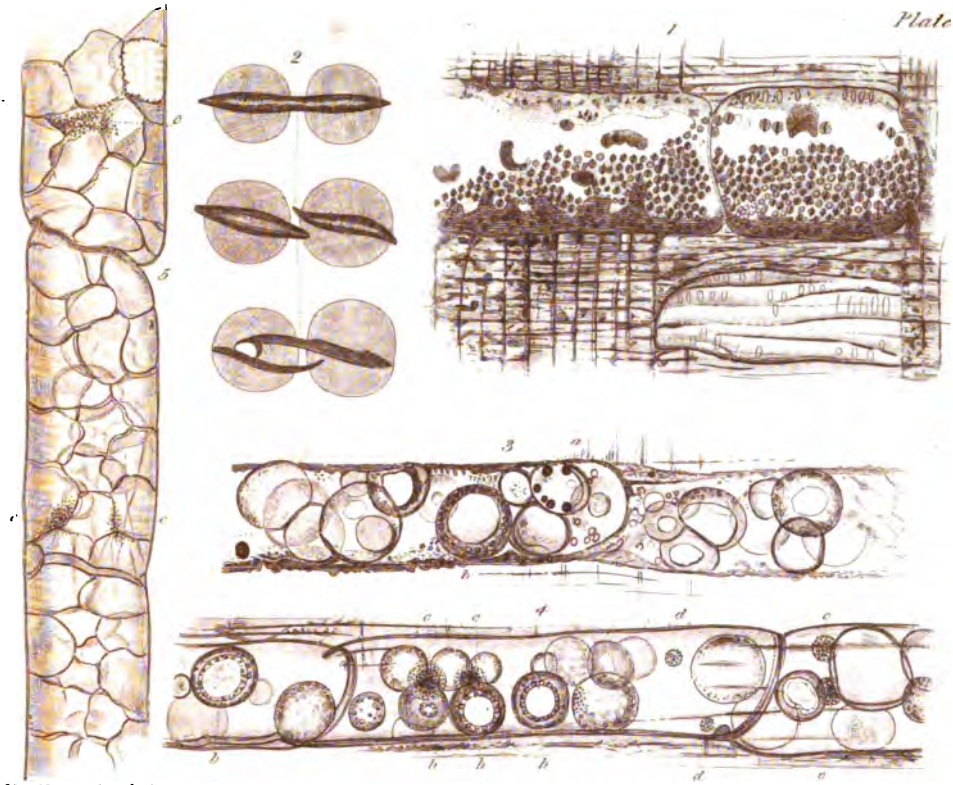

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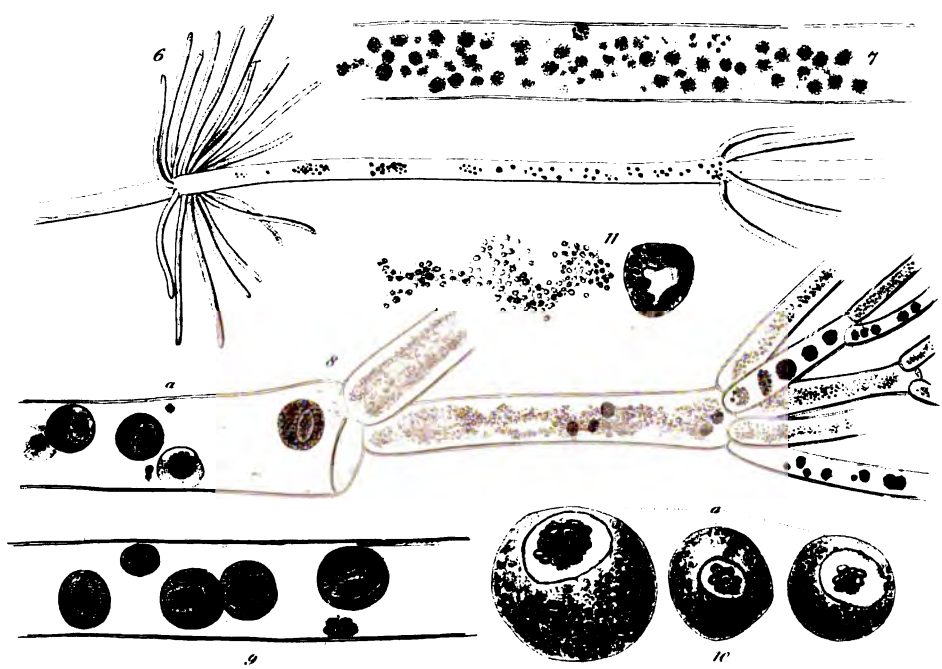

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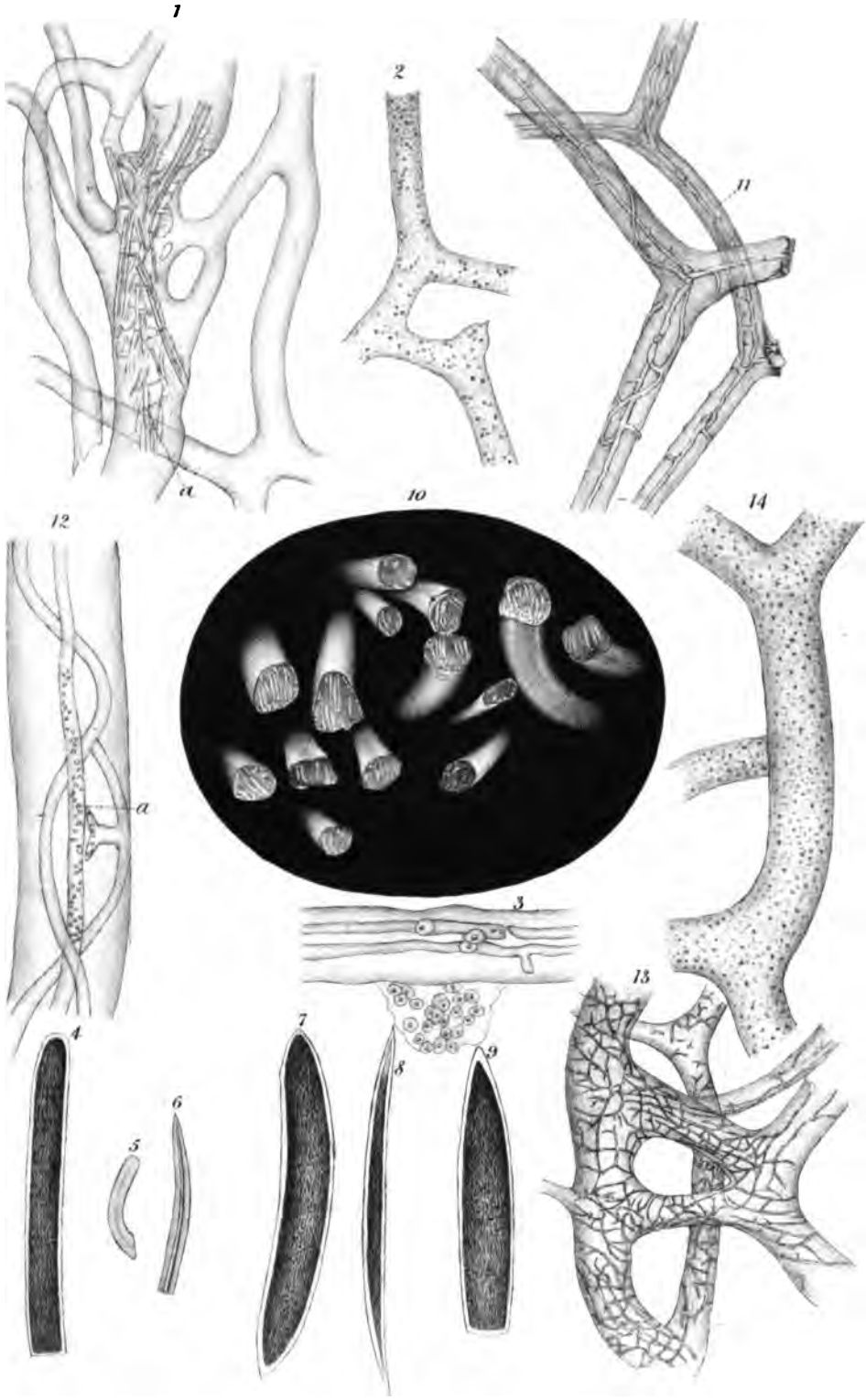
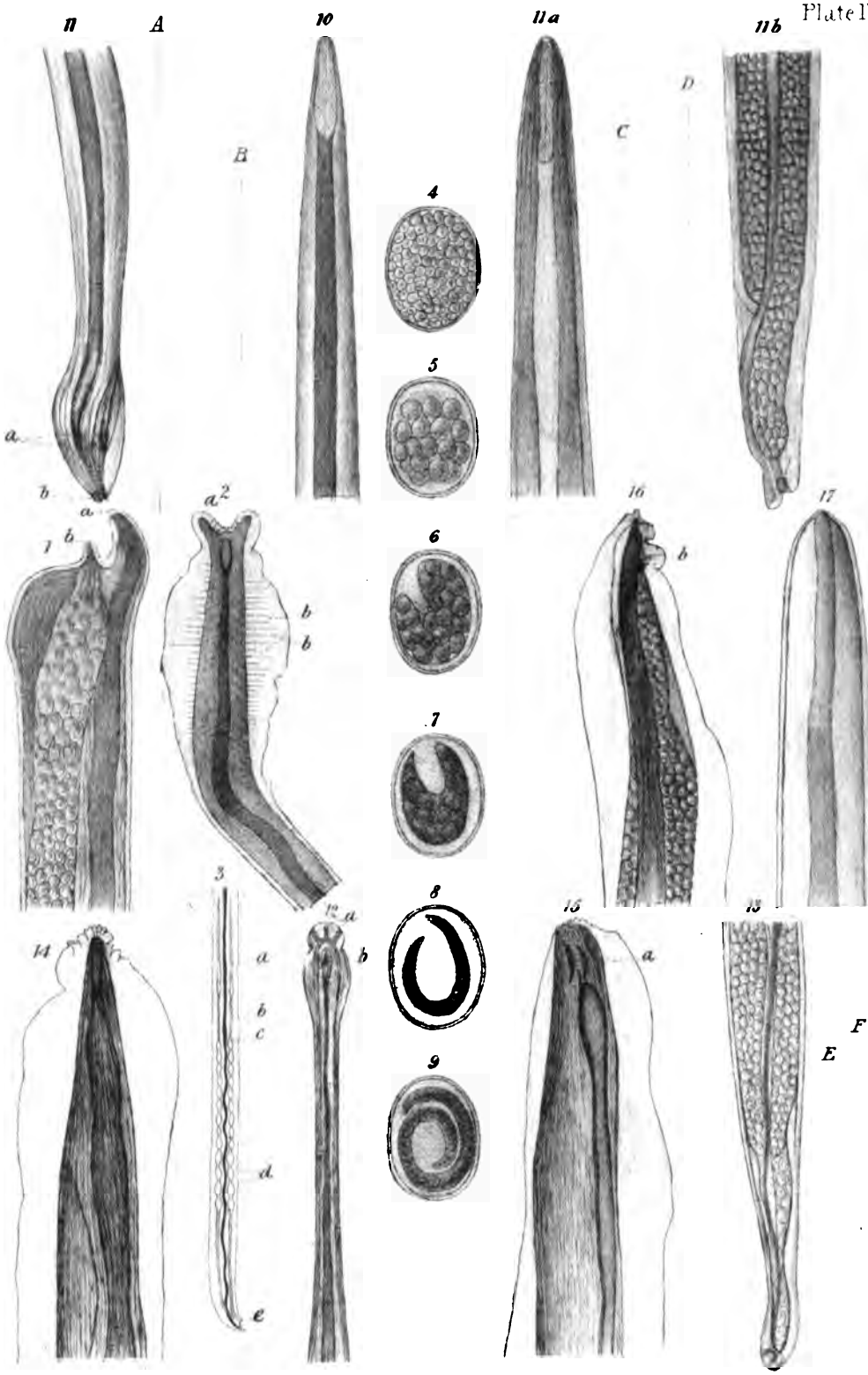


Drawn by Mrs Hattersly.

On Zinc by Lens Aldous

Day & Haghe Lith. to the Queen.

Plate IV



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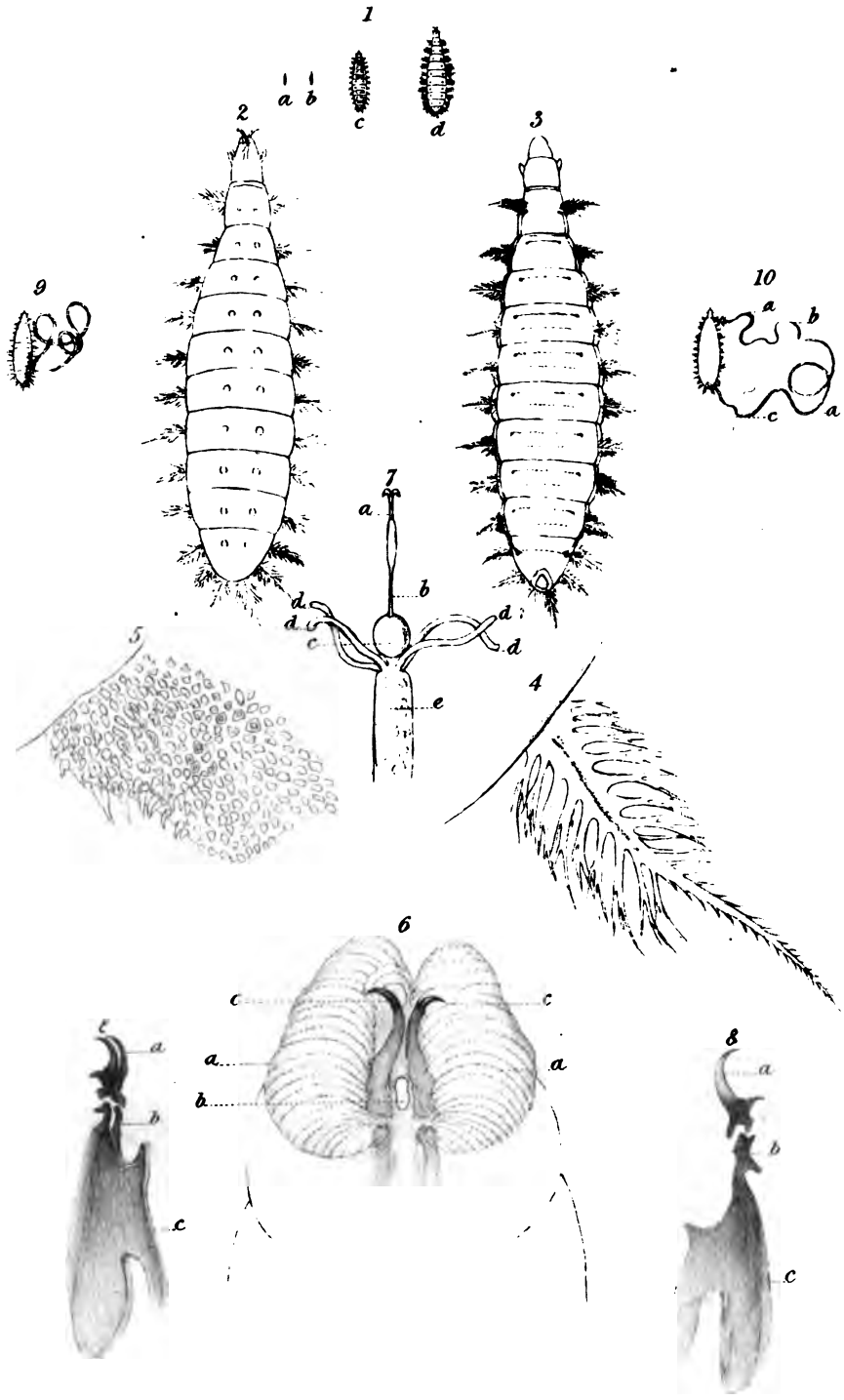
Printed by J. & H. Bell

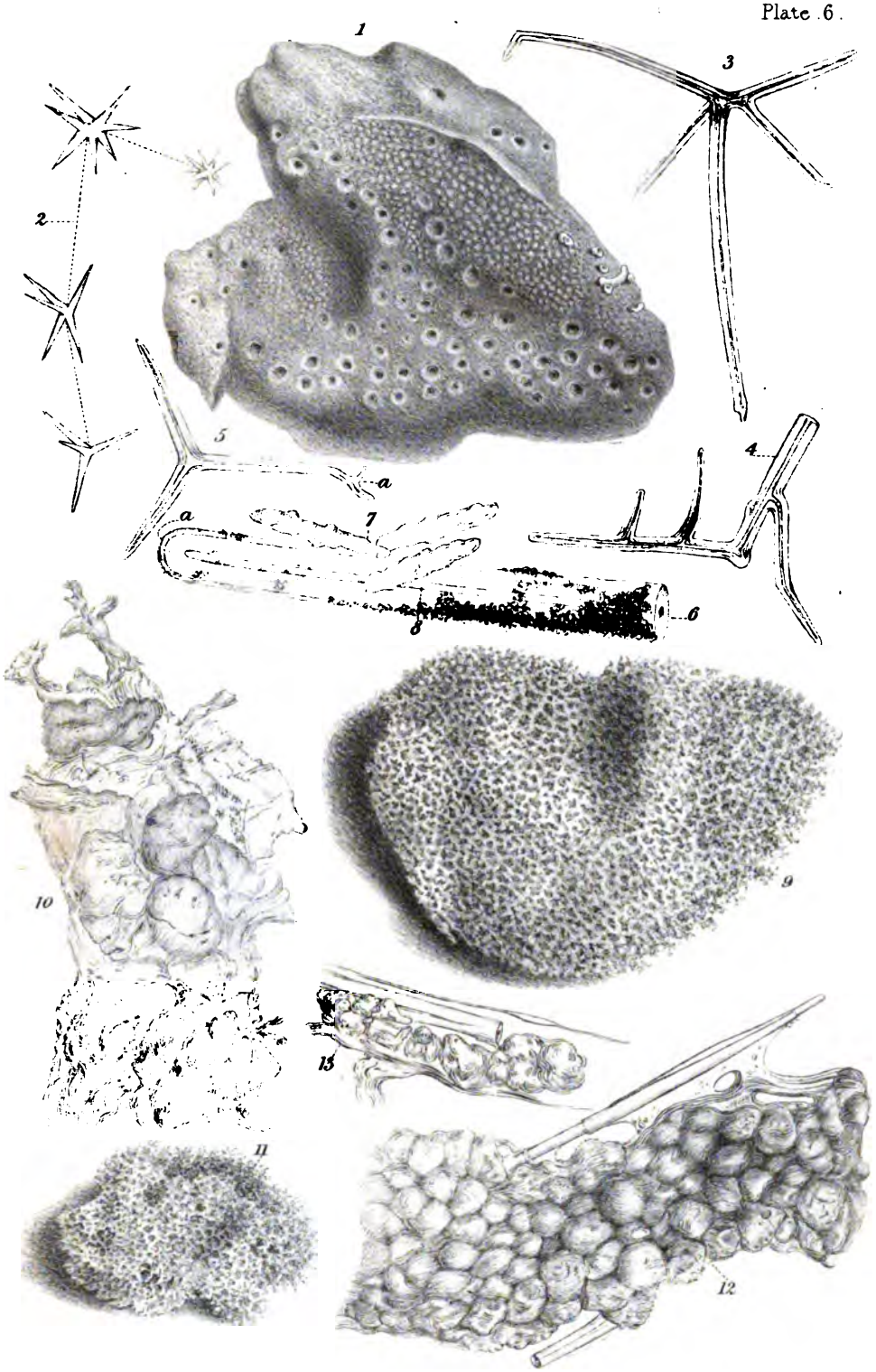


Dr A. Farre, Delin

Lens Aldous, Zinc.

Day & Hagh Lith.rs to the Queen.

Plate 6.



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Lens, Aldous & Jnc

Day & Haghe Lith.rs to the Queen.

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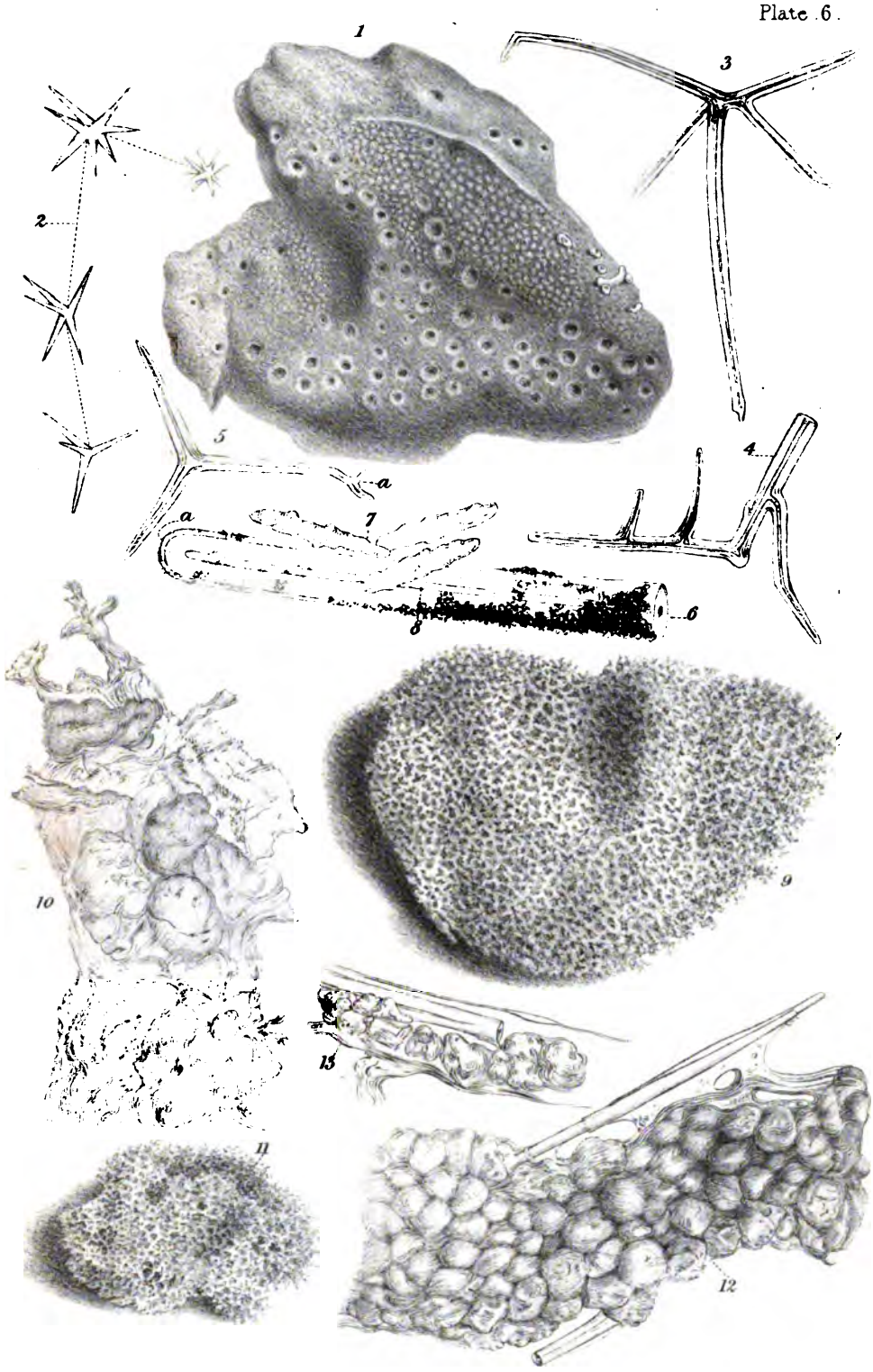

S. W. Leonard, delin.

Lens Aldous, Imp.

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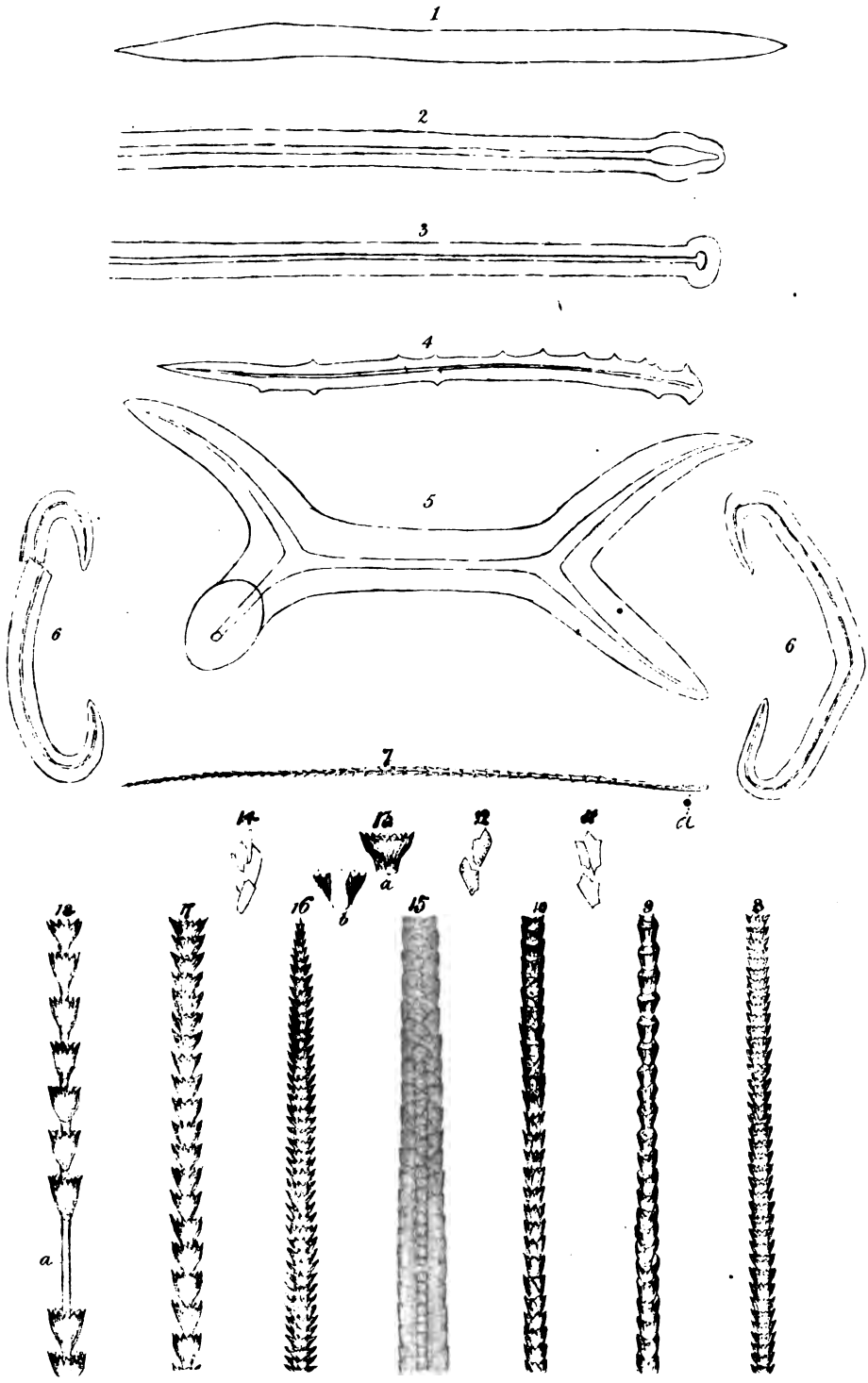
Plate 7.



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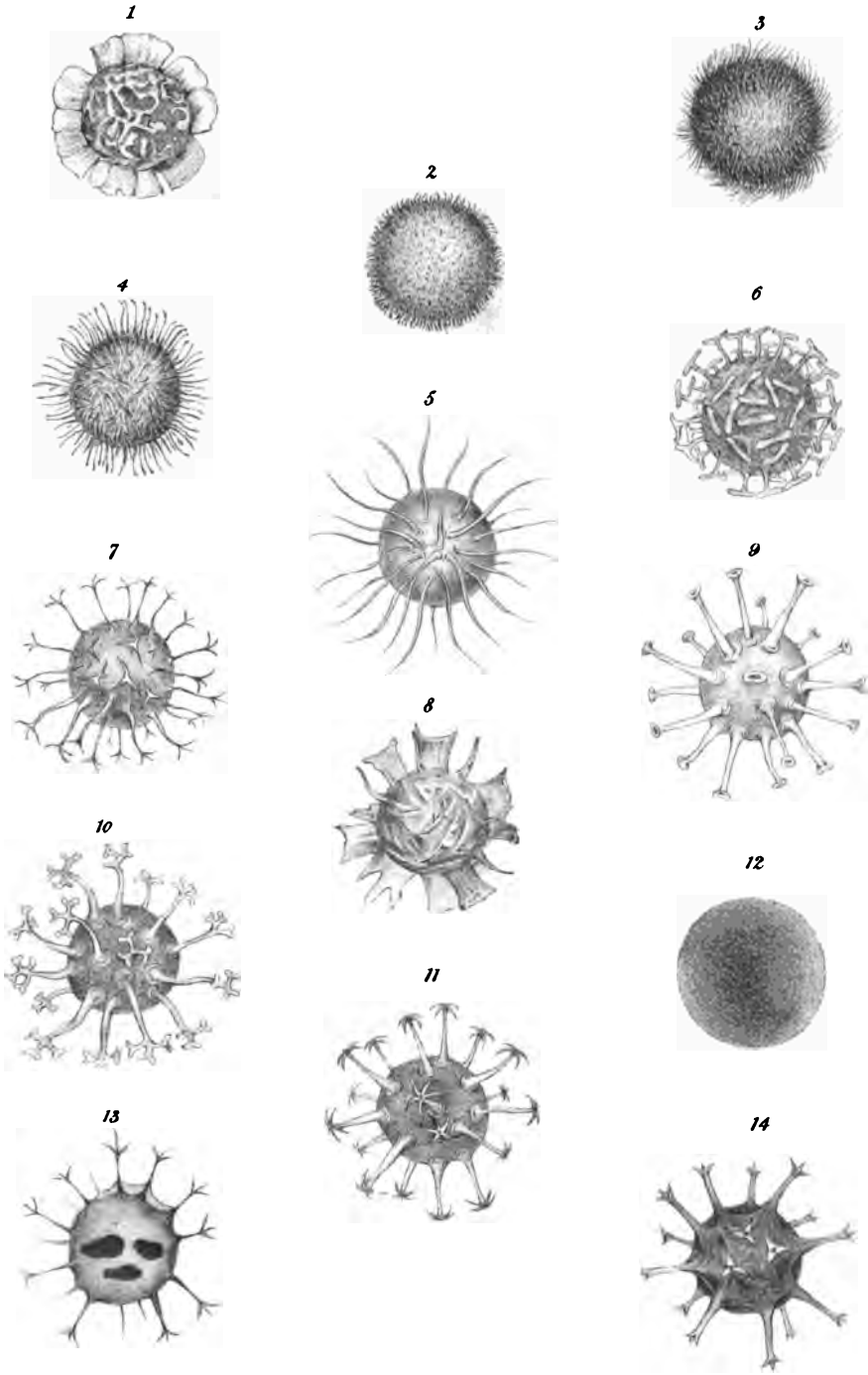

H. H. White Esq.re del.

Day & Haghe Lith.rs to the Queen.

Lens. Aldous Zinc.

Plate 9.

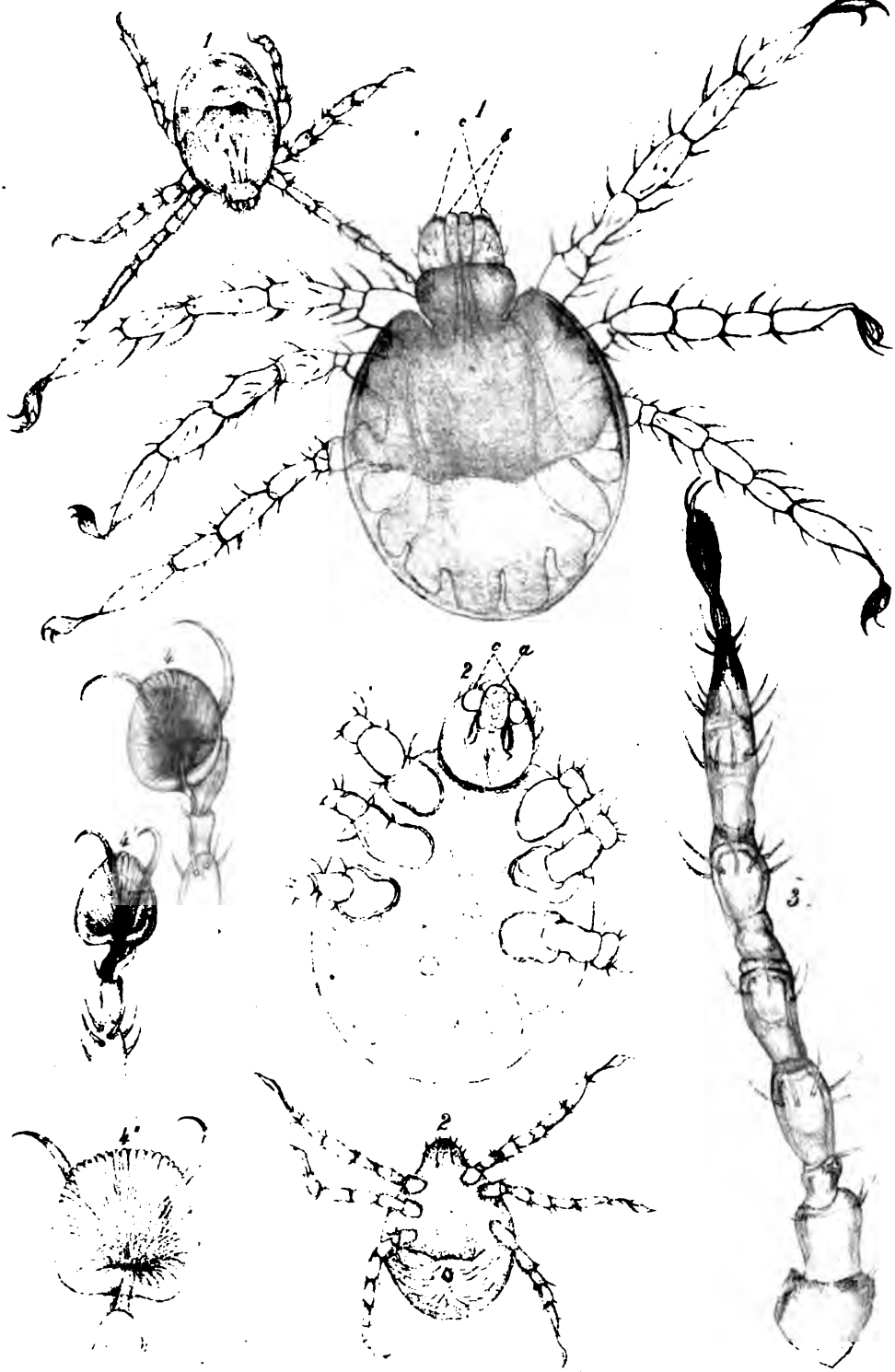

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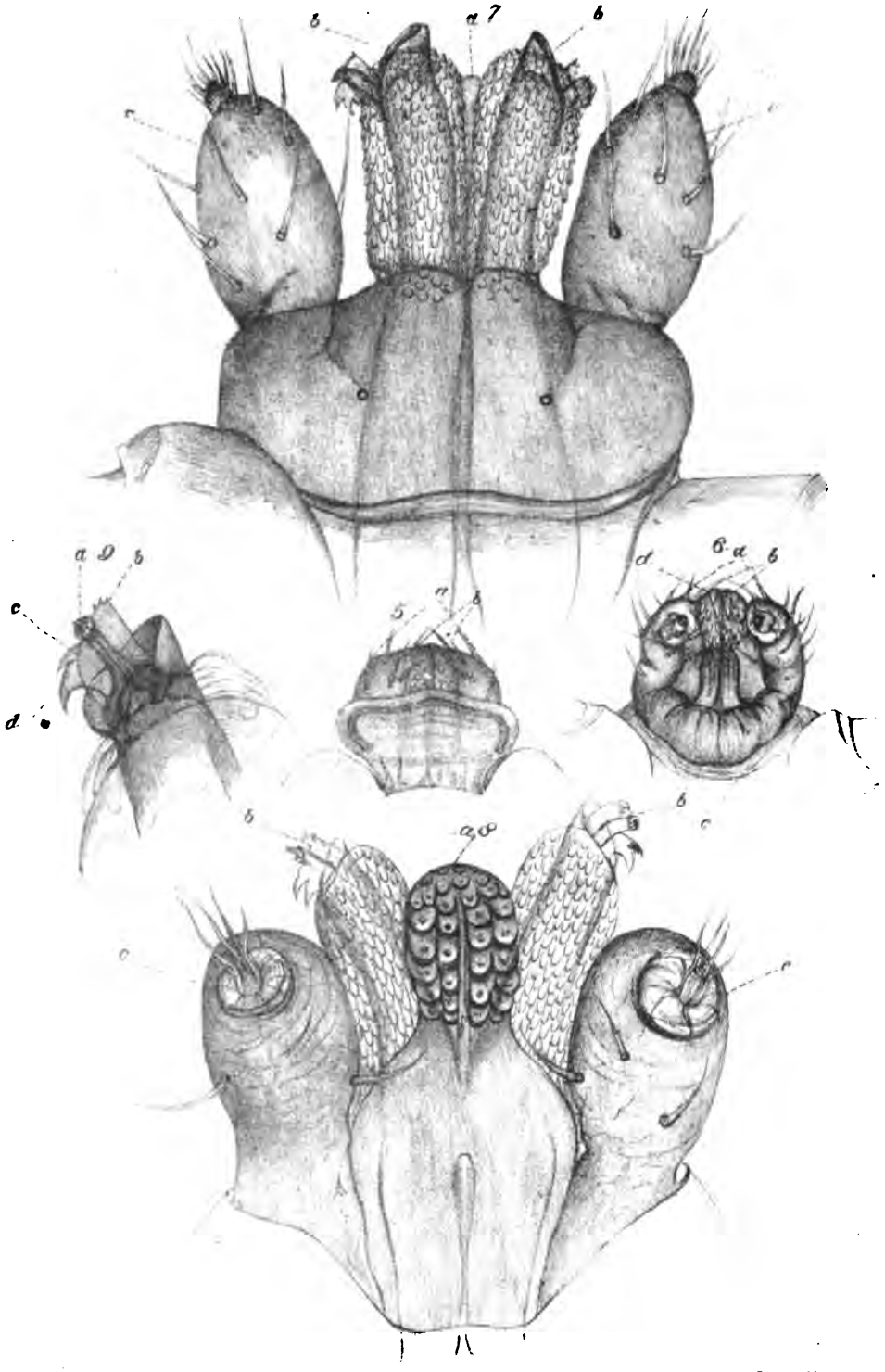
Plate 10.



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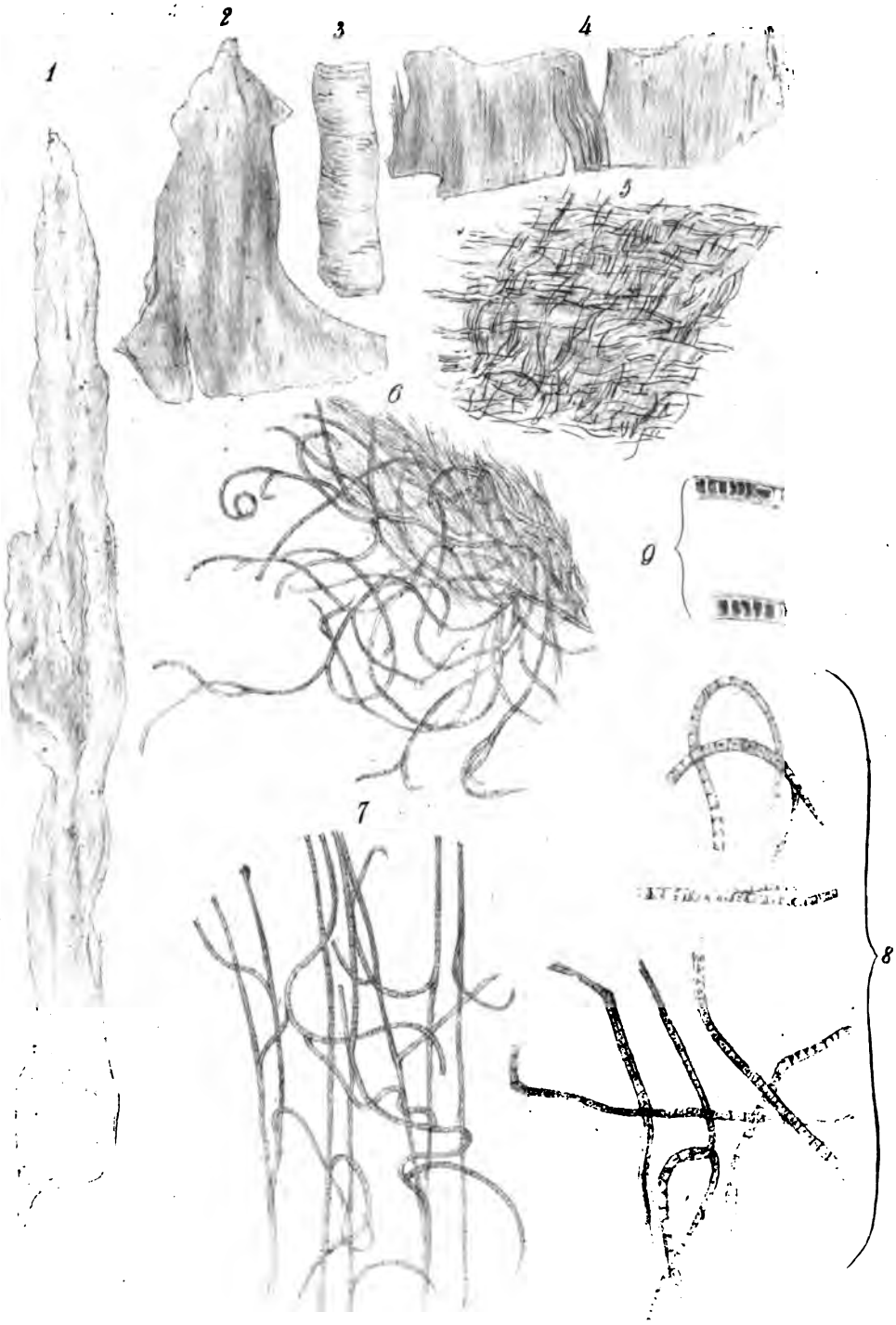
Lens Mdrn: Zinc.

Plate II.



D.A.Farre delin.

Lens Aldous Zinc.

Plate 12.

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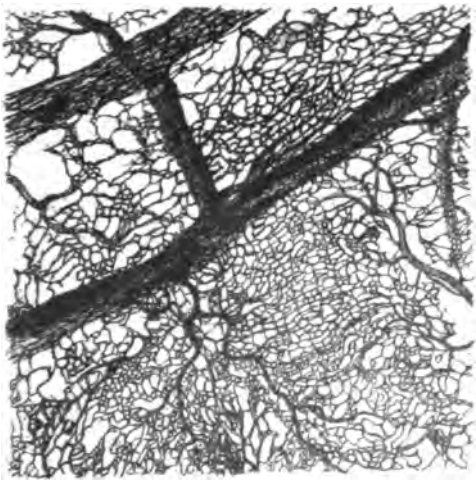

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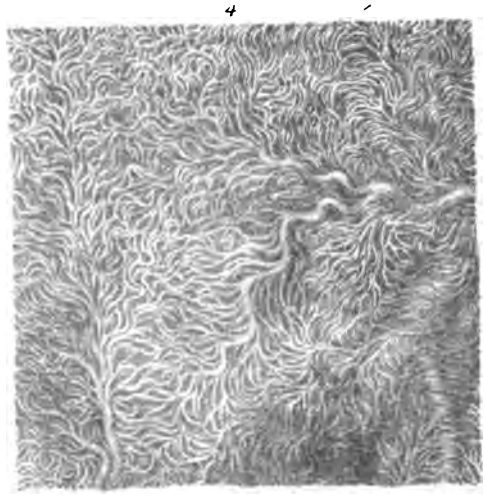

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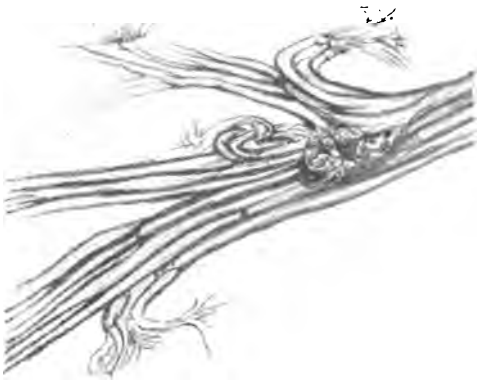

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Plate 12.

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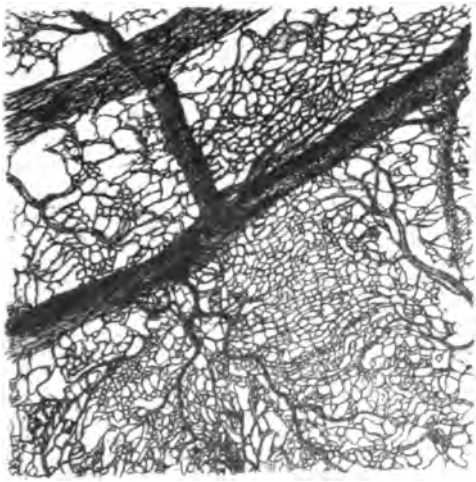

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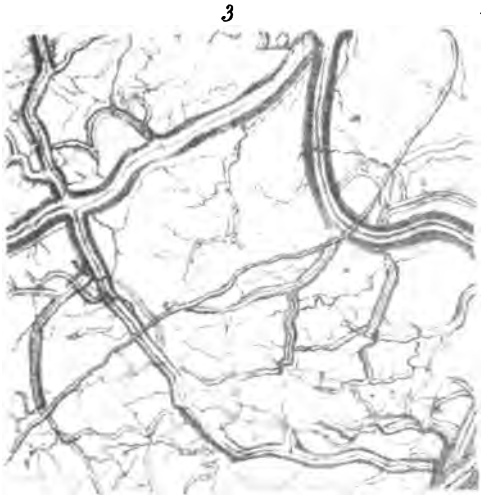

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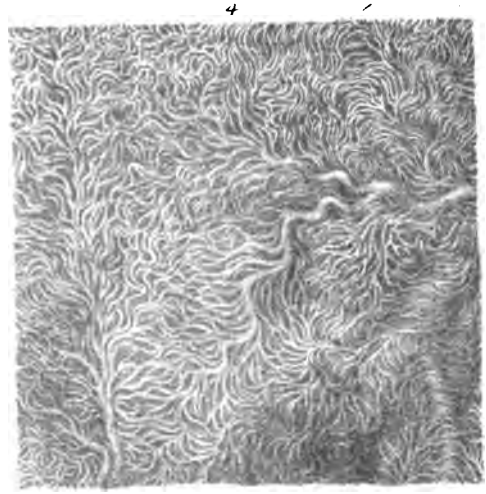

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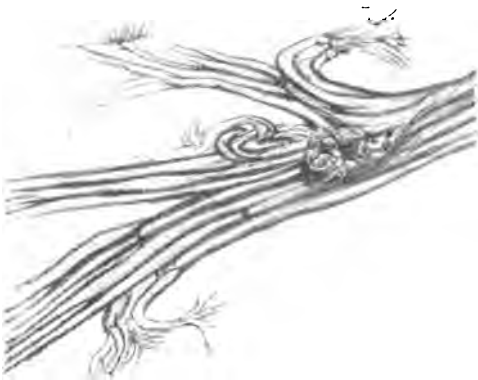

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Lens Aldous del et zinc.

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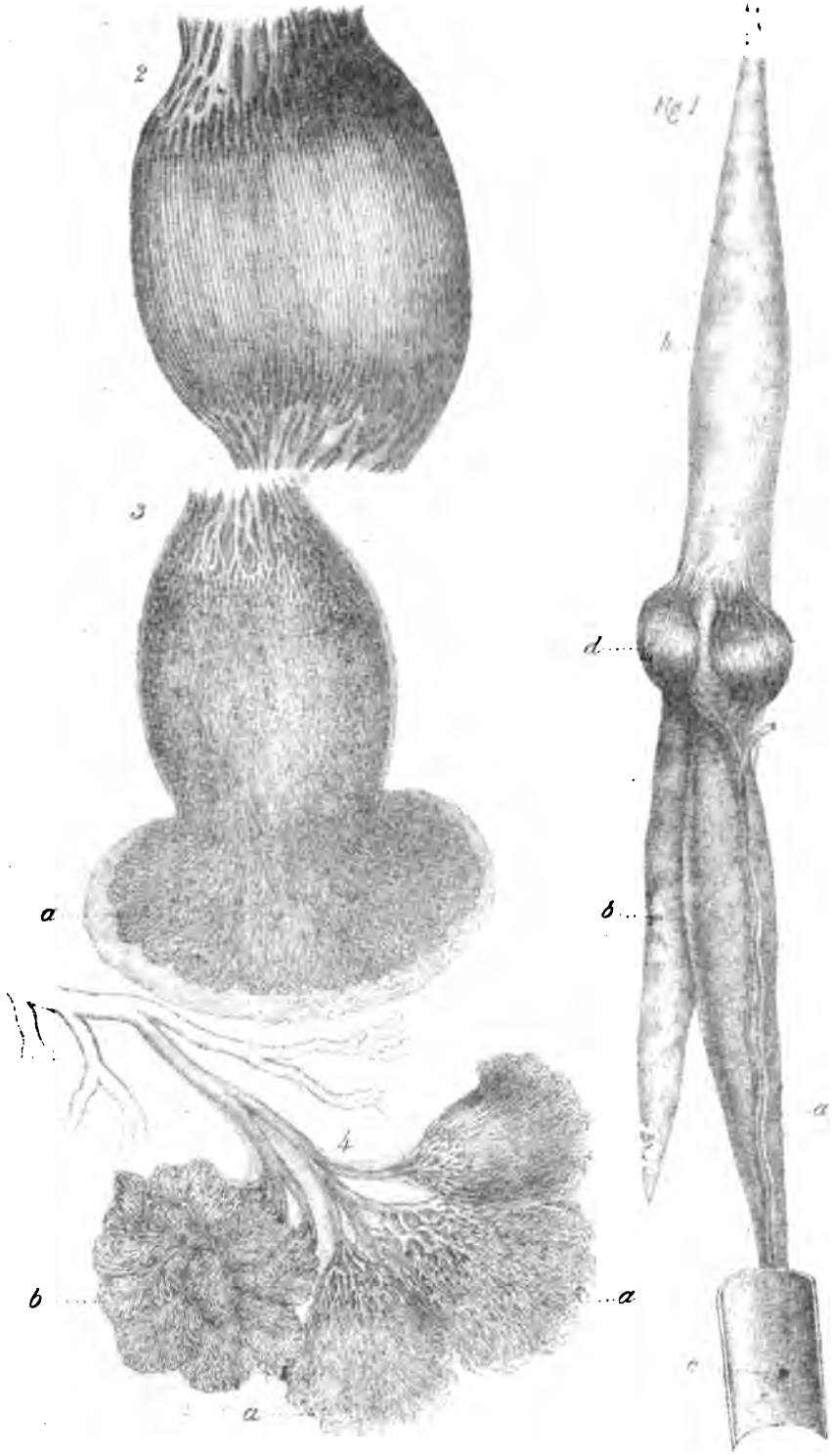

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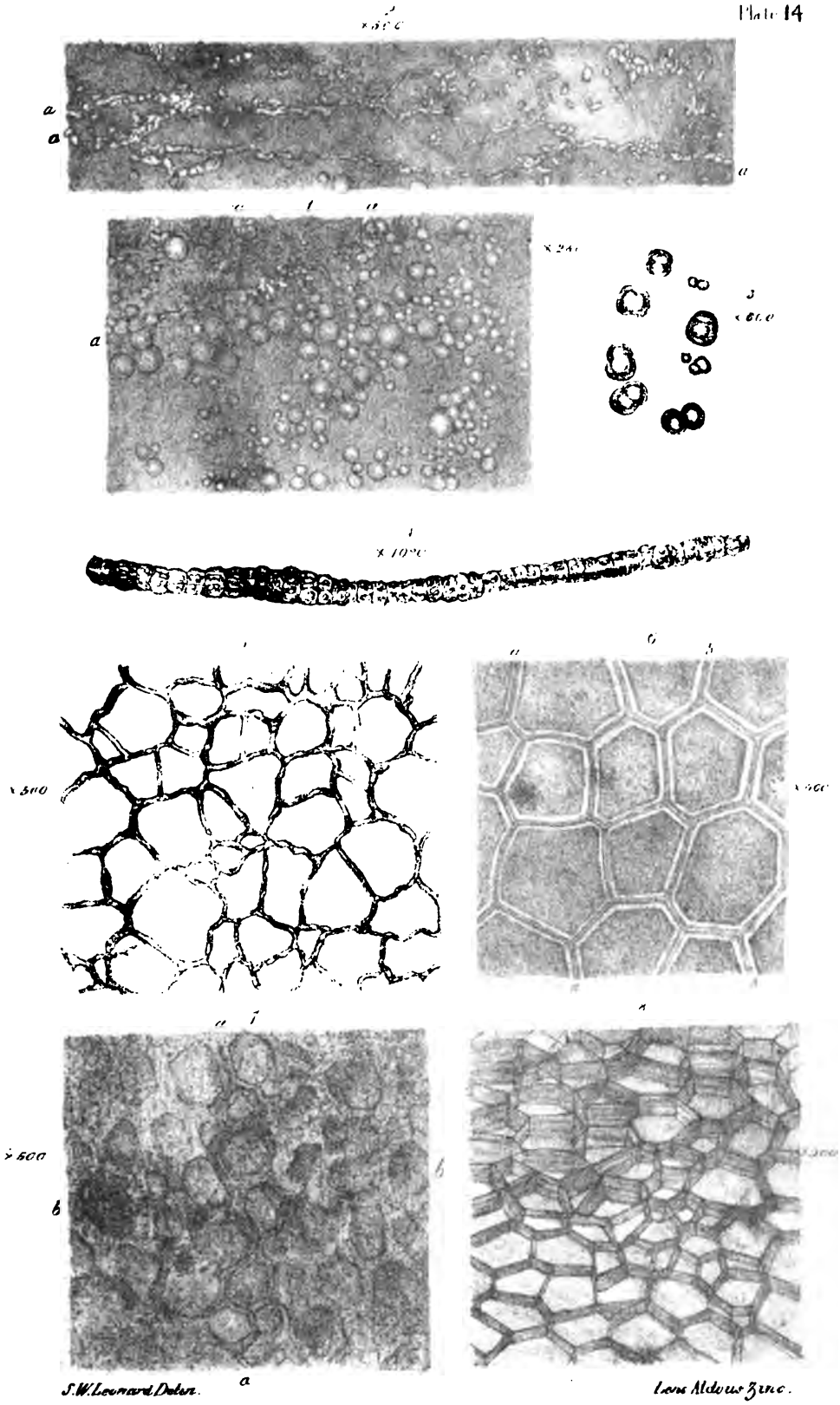

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Lens Aldous Zinc.

Plate 15.

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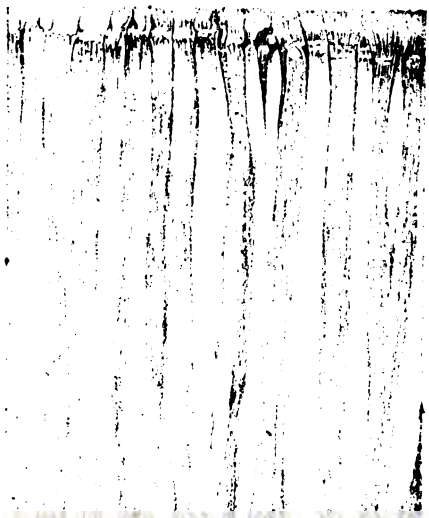

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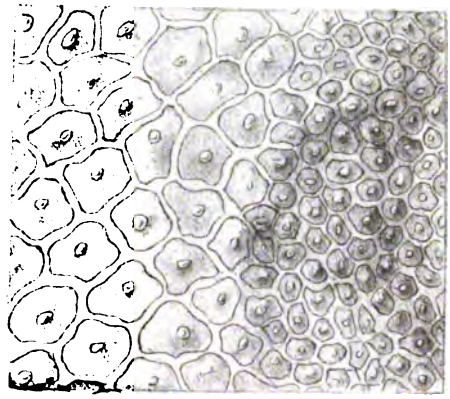

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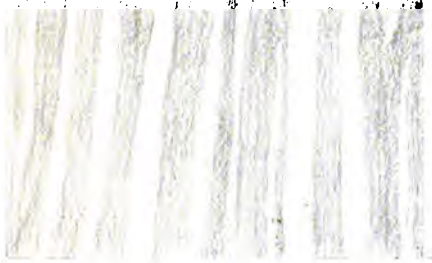

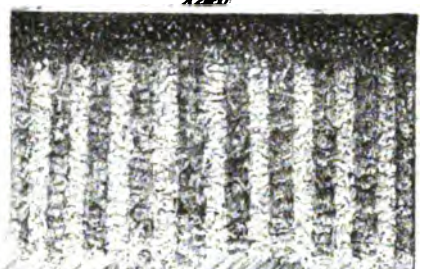

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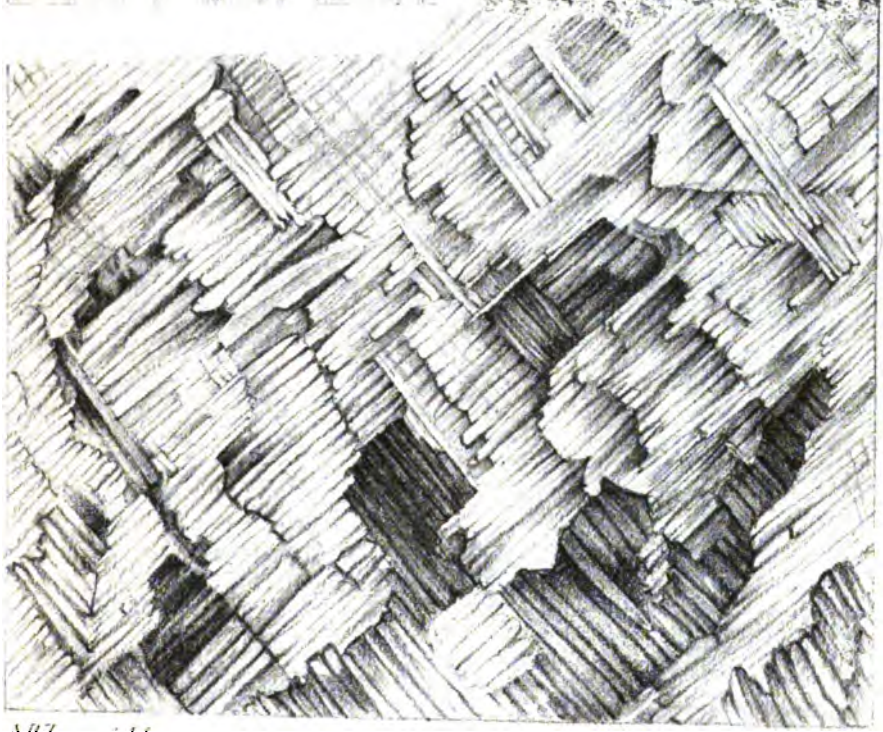

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Plate 10.

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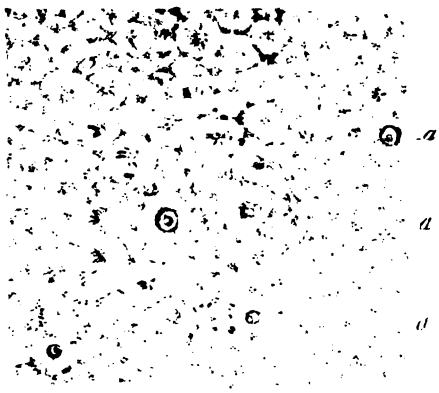

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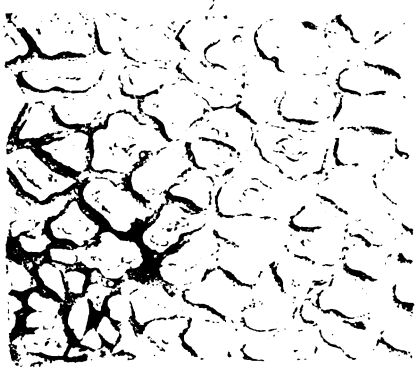

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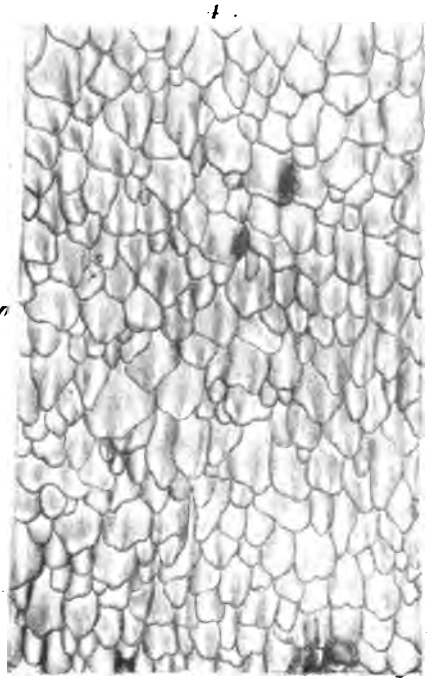

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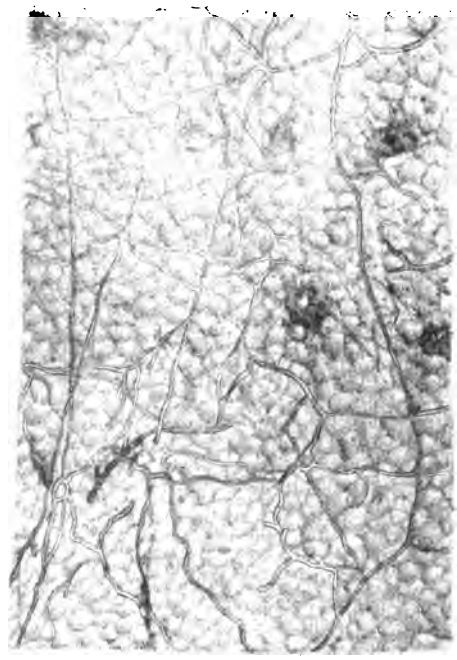

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Lens Aldous Sinc

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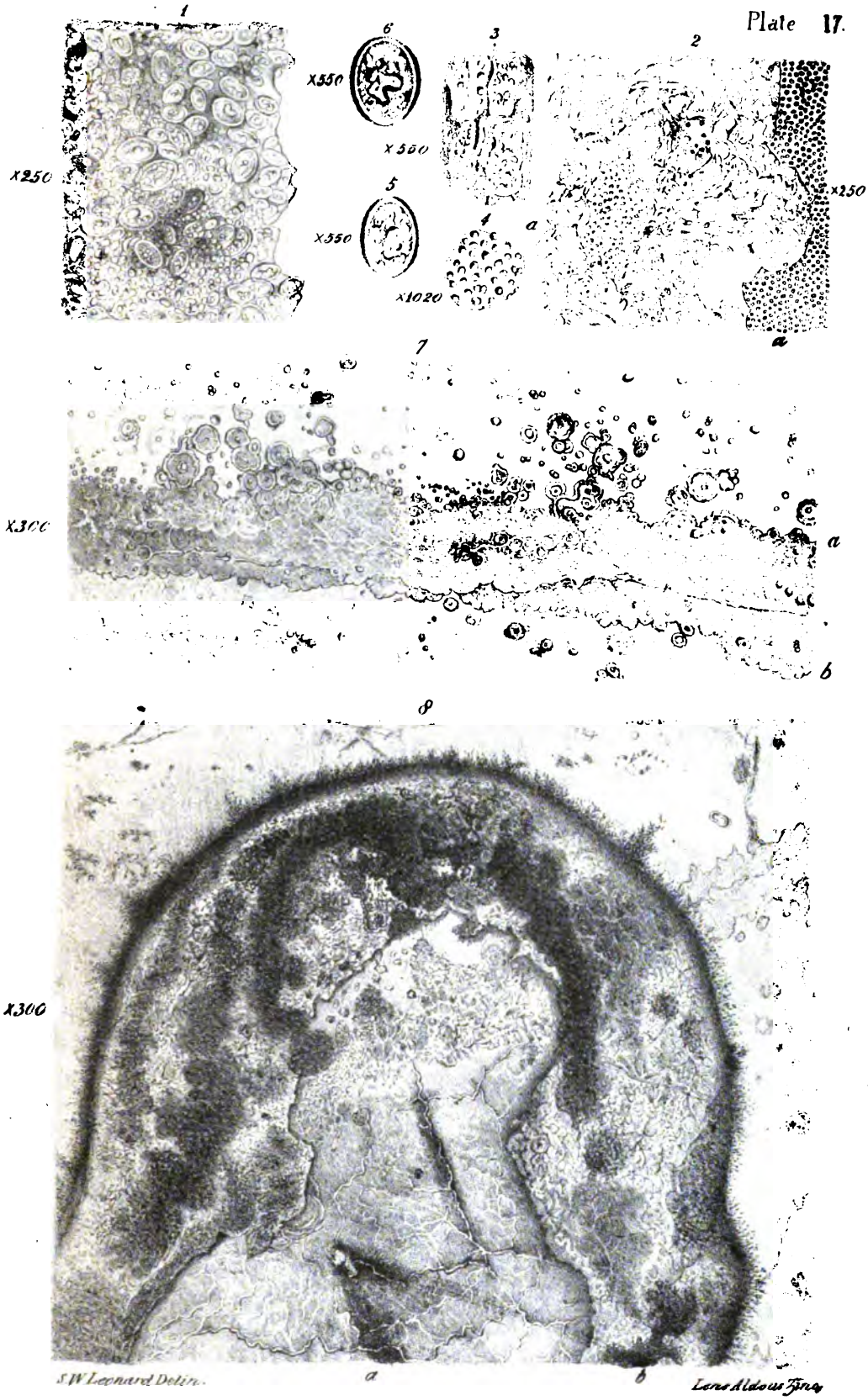

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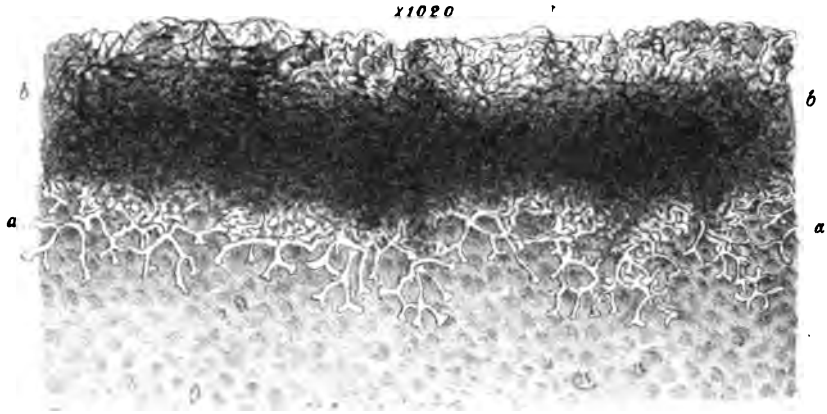

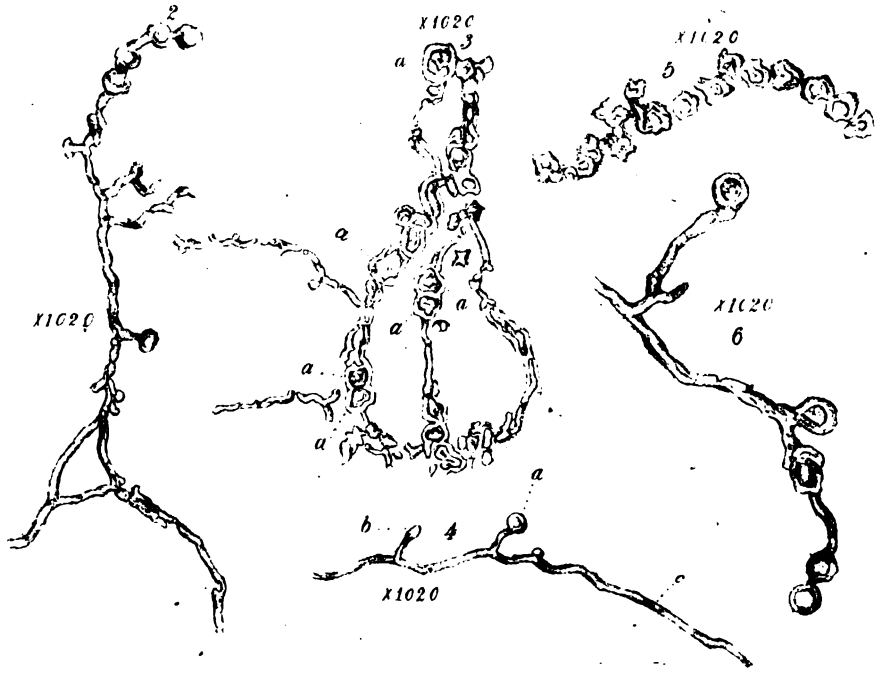

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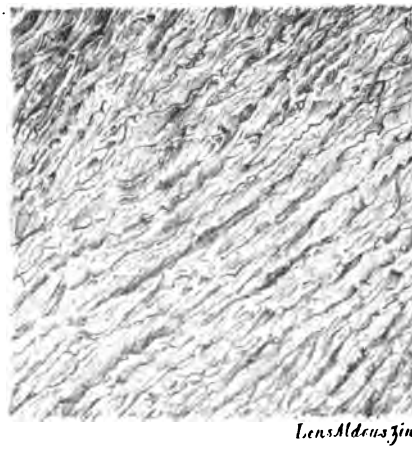

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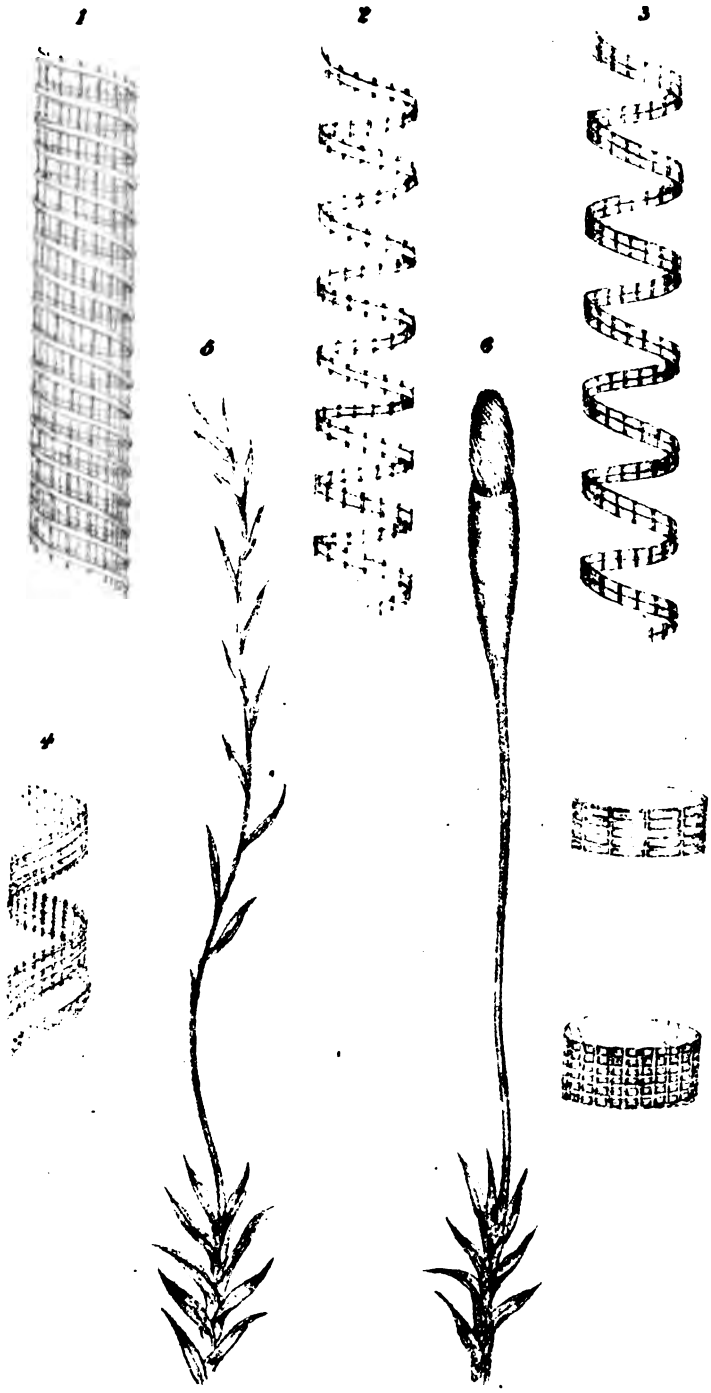

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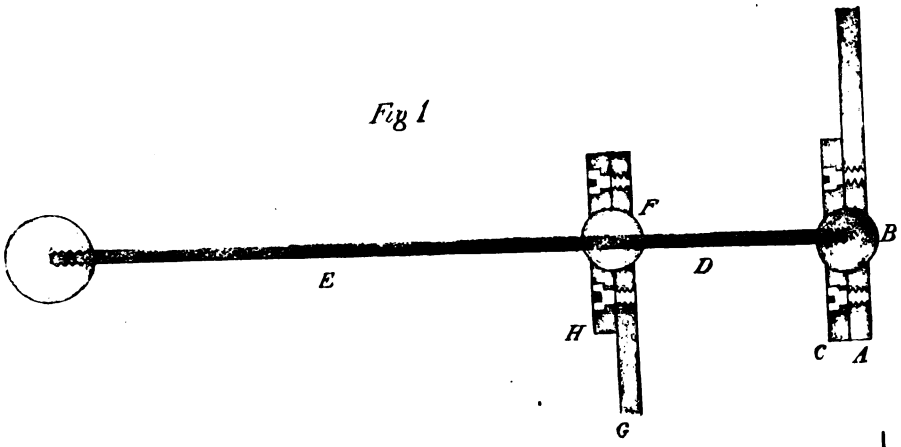
Plate 20.

Fig 1



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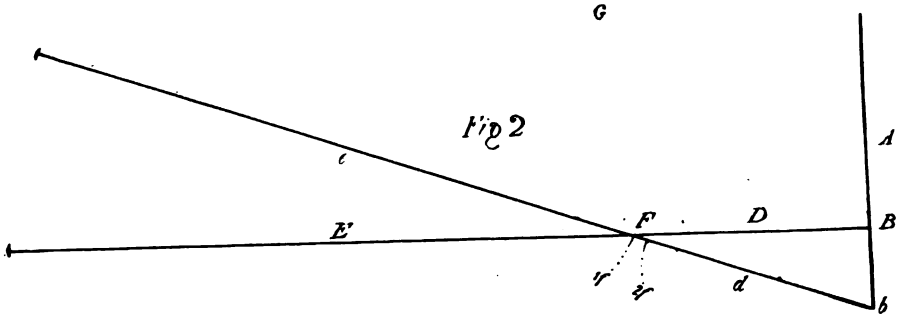

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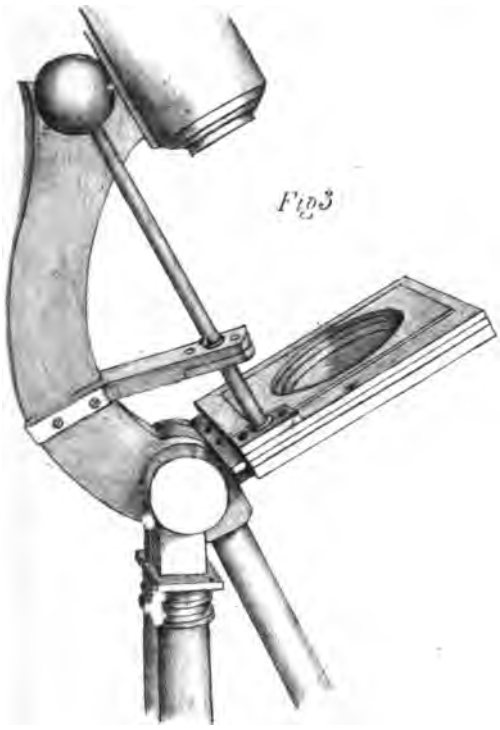

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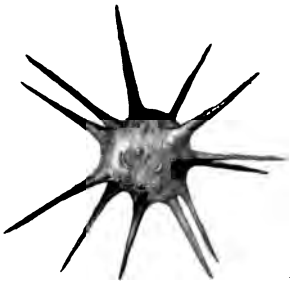
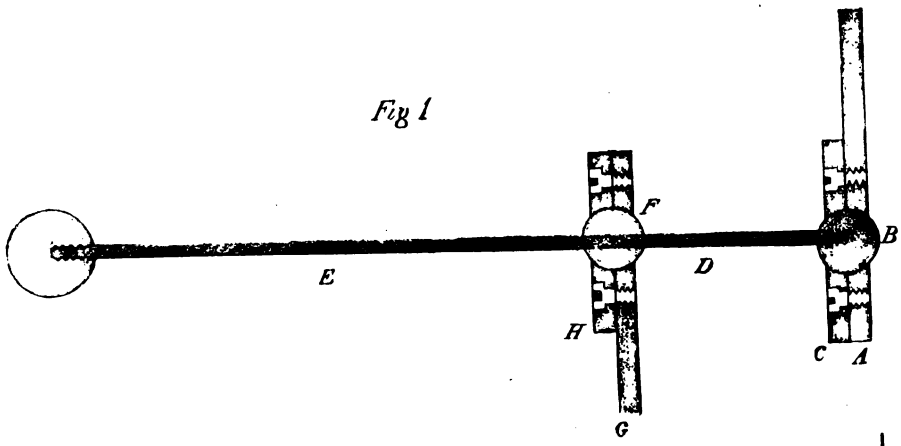


Lens Aldous Zinc.

A. White Eng^d delin.

Plate 20.

Fig 1



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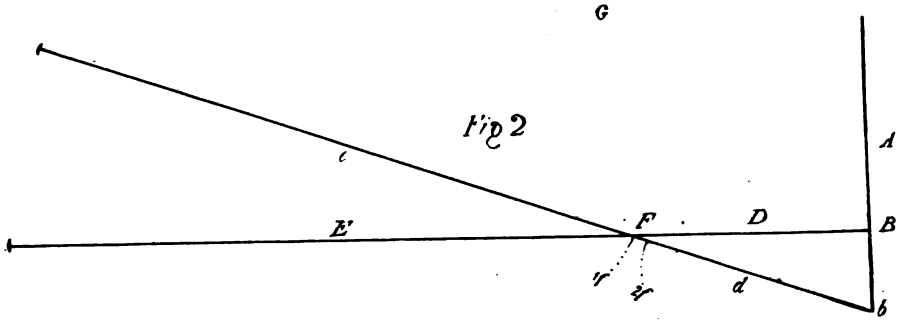

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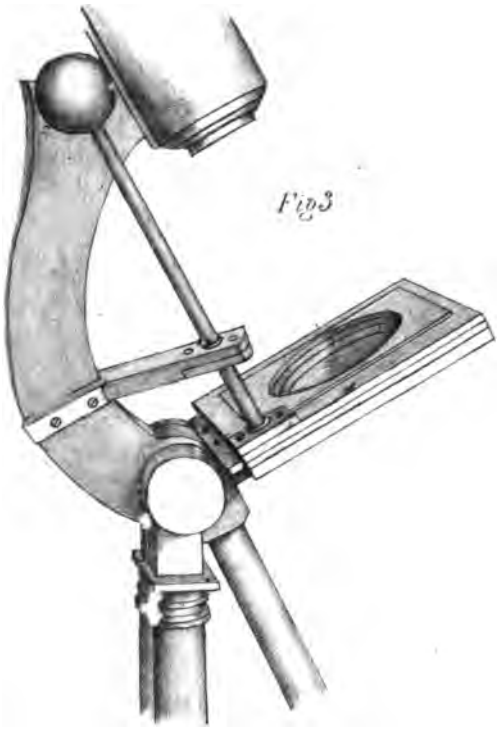

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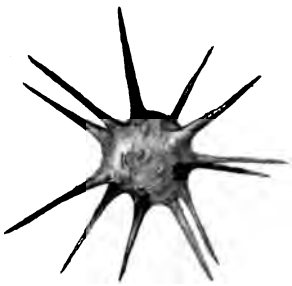

A. White Esq.r del.in.

Lens Aldins Sinc.

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